MODEL RAILWAY POWER SIGNALLING AND POINT OPERATION

E. F. CARTER

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Other Model Railway Books by E. F. CARTER

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PREFACE

THE second world war, when it commenced in September, 1939, prevented the appearance of this, the second part of *Electric Model Railways* ; and the great strides which have been made since then, both in model railway operation and in the methods of remote control generally—as evinced in the spate of radio and electronic control apparatus evolved during the war period—have urged the writer to re-write the original manuscript in its present form.

Although various methods of electrical and pneumatic signalling have been touched upon briefly*, there has, as yet, appeared no really comprehensive work dealing *exclusively* with model power signalling and point operation; and the present work aims at covering the whole field in simple non-technical language, in such a way that even the model railway enthusiast who is not electrically-minded will have no difficulty in understanding how to make and wire into his layout the apparatus necessary to enable his points and signals to be operated by power.

Entirely new ground has been broken in Chapter Six, where the immense possibilities of electronic " light ray " control are dealt with, as well as the making of simply-constructed valve amplifiers suitable for the operation of engine whistles and other uses; and it will quickly be appreciated how simple is the construction of the apparatus

* *Model Railway Signals* and *Practical Two-rail Electrification.*

required, and how wildly exaggerated have been the reports as to its technical and constructional complexities.

If this—which is, in effect, the second part of a very popular work—inspires the model railway owners to make still further use of that willing and flexible servant—electricity, it will have achieved its purpose, as well as becoming a worthy successor to *Electric Model Railways*, of 1939.

ERNEST F. CARTER,
Warlingham, Jan., 1950.

CHAPTER ONE

IT is usually not very long before the most enthusiastic owner of a model railway—whatever its scale or method of drive—becomes conscious of the fact that his rod-operated points and wire-worked signals are a more fruitful cause of operational failures than all the rest of the railway apparatus put together. Mysterious derailments and inexplicable collisions frequently occur, and it is often well-nigh impossible to place one's finger accurately on the underlying cause of such troubles, which are, in nine cases out of ten, due to mechanical point and signal failures.

These troubles, which are noticeable on even the smaller and less complicated layout, are in the main caused by the expansion and contraction of the point-rodding and signal wires or threads. If the layout is located in a loft or other site where the seasonal temperature and humidity changes are excessive, this problem becomes almost impossible of solution, and points which partially open or close, and signals which exhibit a very "half-hearted" indication become common faults.

During the past fifty years, model railways have evolved considerably, and there have been many alternative mechanical point and signal operating schemes suggested, most of which were founded upon prototype mechanical practice and incorporated various methods of compensation for temperature changes. But when all is said and done, the amount of additional constructional work

involved in semi-prototype compensation is considerable; moreover, its use tends to complicate matters still further by introducing any number of working bearings, whilst not always providing an infallible cure for the trouble as it exists in model form.

The primary cause of the great difficulty of obtaining a 100 per cent. perfect mechanical action (in small scales) by which the variations in the length of control rodding can be effectively compensated is shown graphically in

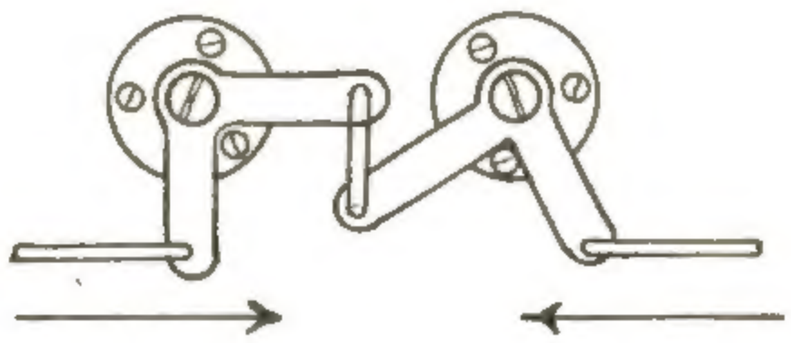


Fig. 1

Fig. 1. It will be seen that, on the two sets of levers necessary to effect compensation without reversal of operating direction, there are no less than twelve moving bearings ; each of which must be an absolutely perfect running fit if motion is not to be lost and successful operation achieved. Moreover, it will also be readily appreciated that any looseness in these bearings is cumulative, being still further amplified by the action of the levers.

Similarly, the use of thread (instead of thin wire) or thin twine for the operation of signals is attended with irritating troubles caused by atmospheric humidity, the material being shortened in damp, and lengthened in dry weather. In this case, compensation is completely out of the question, without going into very involved methods the efficiency of which, in the smaller scales, is very questionable.

All these objectionable features can be eradicated at one stroke—power operation, and whether the power used is pneumatic (as was installed on the London and South Western Railway) or electric, the results are the

same—complete absence of all temperature and humidity irregularities, particularly in model form.

The use of compressed air for model work was originated over a score of years ago, and in its original form did not find great favour among the then "small scale" modellers, who were at the time following gauge "1," on account of the fine limits of machine work necessary to produce a sound working impeller and motor unit; both the units being of normal piston type, and requiring perfect fitting and adequate lubrication to achieve satisfactory results. Moreover, the original scheme was both clumsy and prone to failures due to minute air leaks in impeller or motor cylinders or in the run of air-line.

Admittedly, pneumatic power signalling eliminates the innumerable bell-cranks, wires, and compensating devices which are associated with manual mechanical model signalling, together with many frail and troublesome fitments; but its use, like that of electricity, implies the use of well-made points with blades which are almost frictionless in their movement, together with an entire absence of grit, though the latter is easily blown or kicked up into the cylinder of the point-motor from the ballasting of the line by passing trains.

Piston-type pneumatic power transmission, then, in the original form evolved by Henry Greenly, and used with such success on Mr. Victor B. Harrison's Gauge "1" railway, cannot be said to be easily made or readily applicable to the 4-mm. and 7-mm. scale layouts with which we are today concerned. It is both necessary to simplify the methods of construction of impeller and motor, and to offer an alternative pair of units which will be capable of amateur construction without resorting to the use of a lathe or other tools which are not to be found in the average model railwayman's workshop. The details of such a system will be dealt with at length in a later chapter, where the production of impellers and motors will be described and illustrated.

Continuing the survey of the power signalling field, electricity comes into the picture; and here is a power which will easily carry out all the work required without any drawbacks, and will continue to do so faithfully so long as electric power is supplied to the equipment.

Quite naturally, electrically-driven model railways lend themselves to the ready installation of power signalling by reason of the power supply being ready to hand, and it must not be thought for one moment that the super-imposition of power signalling equipment on any existing model railway layout—" two-rail," " three-rail," or " stud-contact "—will so complicate or disorganise matters as to make its installation and operation difficult beyond the capabilities of the average model railwayman.

In point of fact, the reverse is the case, for, by reason of the virtual infallibility of power-operated signals and points, together with the extreme ease with which their controls may be grouped together at the main operating point, it is possible for one person to operate quite an extensive model railway with far greater ease and realistic effect than would ever be possible if the points and signals were mechanically worked. This fact has been overwhelmingly proved on the very large " O " and " OO " gauge exhibition layouts, which are, more often than not, under the control of one person for hours at a time.

This virtual elimination of the element of chance means that, if a point or signal is *once* made to work perfectly by power means, it will operate a thousand times with equal perfection, and with but little attention other than occasional lubrication. This is the secret of the outstanding success of power signalling—irrespective of the power used.

The vexed question of signal and point-motor power-supply by no means always enters into the picture, for most of the better-class commercially-built units for the conversion of the house-mains current (as a.c.) into a suitable form (d.c.) for driving electric locomotives, also have a

spare transformer tapping which appears on the power-supply unit panel as two additional terminals (perhaps marked 20 V a.c.). From these terminals low-voltage a.c. current can be drawn for station lighting, or it can be used for point and signal operation, the modifications required for the latter use being capable of addition to the unit with but little alteration. Such work can be done without any great technical knowledge or experience, and the matter will be dealt with in a later chapter.

If, however, such "spare" terminals do not exist on the reader's rectifier unit, it is an easy matter to build up a simple mains unit which will supply, at very low cost, ample power for all the signalling circuits. A low voltage only is required, and thus the wiring does not involve any great insulation problems. In most cases, from six to eight volts is ample, but in cases where steel track and any of the proprietory alloy wheels* are being used, it will be found advantageous to use twelve volts on the point and signal circuits, with a correspondingly low power consumption.† This higher voltage materially assists in the preservation of a good track-circuit contact between the wheels and the rails by more easily breaking through any dust or dirt which may be present, either on the track or the wheels of the rolling stock and locomotives.

There is, in amateur circles, some disagreement over the relative merits and de-merits of direct and alternating current when used for the operation of point and signal solenoids. Admittedly, a.c. can be used—in fact, it is often used for such work, but its use, when applied to electro-magnetic devices of any kind, is always accom-

* Most of these wheels are composed of mixtures of copper, zinc, tin and aluminium; an average proportion being copper 4 per cent., zinc 89 per cent., tin 1 per cent., and aluminium 6 per cent. These alloys have an electrolytic effect upon steel and Sheridised track which tends to accumulate grease and dirt.

† Volts × amperes equals watts. Thus 4 volts at 1½ amps will produce the same power in watts (as electro-magnetic effect in a point or signal motor) as 12 volts at ½ ampere, 6 watts being available in each case.

panied by a very unrealistic growl or hum, caused by the frequency alternation of the supply. Another point in disfavour of the use of a.c. is that, to obtain the same power efficiency, its voltage has to be about twice as great as d.c. when used for the same purpose.

Alternating current, when fed direct to solenoid point-motors, has the disadvantage of causing the point-blades to bounce away from their stock-rails as the operating current is switched off. Not only so, the excessive amount of arcing and spluttering at the lever-frame contacts causes them to pit speedily and eventually to become immovable.

None of these drawbacks appear when d.c. is used, for the production of which quite simple and effective apparatus can be produced by the veriest amateur at electrical work; and the rectifier units required are very cheap to purchase—often as war disposal material.

Direct current, whether supplied by a.c. to d.c. rectifiers, accumulators, dry-cells, or primary batteries, is easy to handle, safe and silent in operation, and can be used at one half the voltage required by a.c. It is, therefore, very strongly recommended for use with all the electrical point and signal apparatus dealt with in these pages.

After this preliminary discussion of the *pros* and *cons* of power signal installation, together with the various ways and means of so doing, the fundamental systems of operation will now be explained, and their relative merits appraised. Broadly speaking, the three basic systems used for point and signal operation of model railways fall into three categories:—(*a*) fully automatic, (*b*) semi-automatic or permissive, and (*c*) manual or independent. These three systems may be further explained as: (*a*) trains working their own signals and points without any interference on the part of the operator, other than " driving " (i.e., speed control and reversing); (*b*) trains working signals, but points worked manually from electric lever-frame. Points and signals interlocked electrically, if desired; with connection to locomotive power-supply at

certain points, and (*c*) electric points and signals worked manually from an electric lever-frame, with no connection of any kind between the signals and the trains—entirely independent in every way, other than, perhaps, the signal power-supply being drawn from the locomotive traction power-supply-unit transformer.

Of the three principles, undoubtedly the "permissive," or semi-automatic is the most popular in Great Britain, though in America, and on some English exhibition layouts, some form of fully automatic system is frequently used, so that a continued display-cycle of events can be repeated, *ad lib*, with little or no attention on the part of the operator.

However, in the writer's opinion, there is not much interest in a model railway that "runs itself"—without any fear of accidents, and without any skill on the part of the man at the controls; for one of the most intriguing features of a fully electric, yet semi-automatic model railway is the amount of continual care and vigilence necessary to drive even two trains at the same time. It needs concentration, as well as a thorough working knowledge of the layout being operated. Every point control, every electrical section and signal must be precisely known and memorised if a good showing is to be made. On really large layouts, the writer has often proved the utter impossibility of trying to read the *Model Railway News* and run four trains at the same time! Something is bound to happen. Howbeit, there are those who may feel irresistably drawn towards wiring up a fully automatic layout, and the various ways of attaining this end will be dealt with later in detail.

The "independent" system of point and signal operation is, as its name implies, *entirely* independent of all train speeds and movements, and it thus permits trains to run against conflicting signals, though the latter may be locked in with the points they cover—the locking taking place either at the points or signals themselves, or in the lever frame.

Such a system is eminently suited for operation by two persons—one at the locomotive controls, and the other in the main signal-box. Under such working, it behoves the driver to read his signals correctly and act accordingly, or else . . . !

Weighing up the three systems, there seems little doubt that some form of permissive, semi-automatic signalling is what is required by the vast majority of model railwaymen, together with partial locking-in of points where converging roads are apt otherwise to conflict. But, be that as it may, whichever system the reader decides upon, it is absolutely vital that there should be no *volte face* after a start has once been made; for, unless *one* basic system is carried into adoption without any promiscuous admixture of other schemes, it will be found that the involved circuiting will get into such a tangle that the owner may well wish that he had left power signalling severely alone. Choose your system and stick to it is the best advice which could be given to the beginner in power signal and point operation.

CHAPTER TWO

ALTHOUGH there are on the model railway market several electro-magnetic point and signal motors of excellent design and manufacture, there are probably many model railwaymen who may decide to set their face against the use of ready-made gear, and will prefer to make up their own motors for themselves from raw materials. There is no gainsaying the fact that there is an added sense of achievement to be felt when using a working unit which has been built up " from scratch," and it is to those who have set their minds against " prefabrication " that the following constructional details and description are primarily addressed.

The amateur making of simple electric motors for the operation of signals and points in " O," " OO " and " 1 " gauges is by no means the insurmountable problem that one could well be led to believe; and, as size—within limits—does not affect the usage of units, if they are mounted beneath the railway baseboard, it will be found advantageous to let the first effort be made to the size shown in Fig. 2, working to the general design of Fig. 3.

It will be seen that the main body-tube of the point-motor shown is made from sheet metal, bent into a square-shaped tube, No. 24 s.w.g. sheet brass being used for the purpose. The sheet should be annealed before bending (if a sample bend shows any signs of cracking) by heating to a dull red in a gas flame. The overall size of the sheet required for one motor is about 3 in. × $1\frac{5}{8}$ in., and the

outline and bending lines should be carefully scribed thereon before attempting to cut out the shape. The slots *A* and *B* for the cross-slide, and *C* and *D* for the main armature slide should be cut out by drilling a hole at each end of each slot and working across with a parallel needle-file, all such pierced work being carried out before bending the sheet into a rectangular tube. The slotted end at *C* should be detached from the main sheet, so that it can be

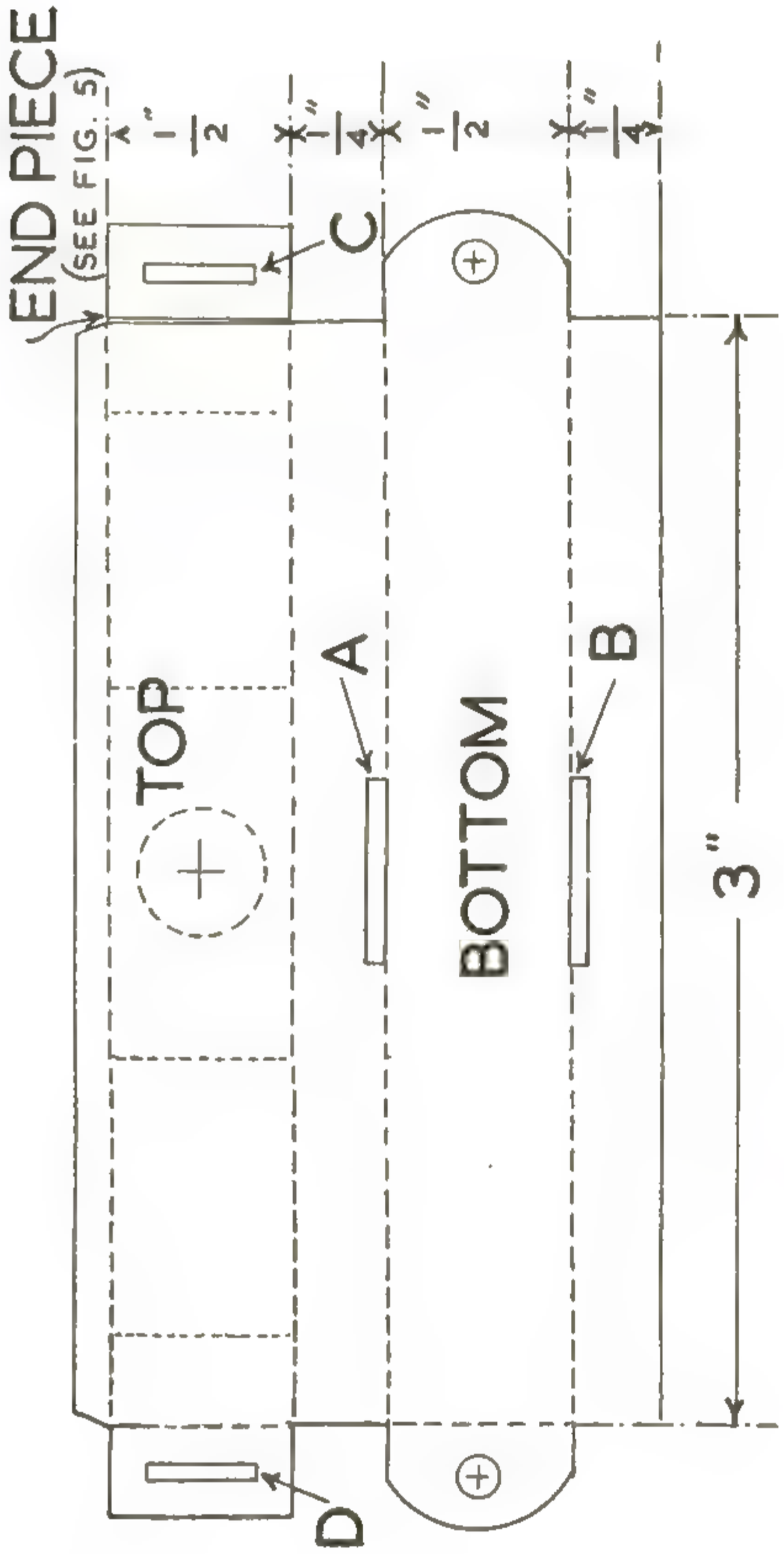


Fig. 2

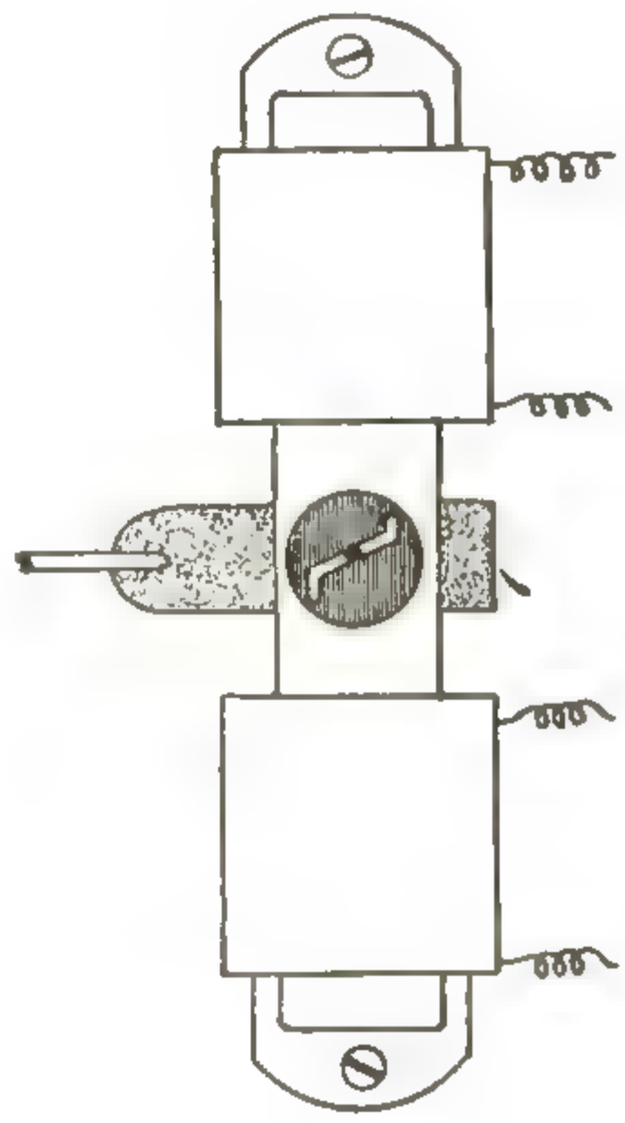


Fig. 3

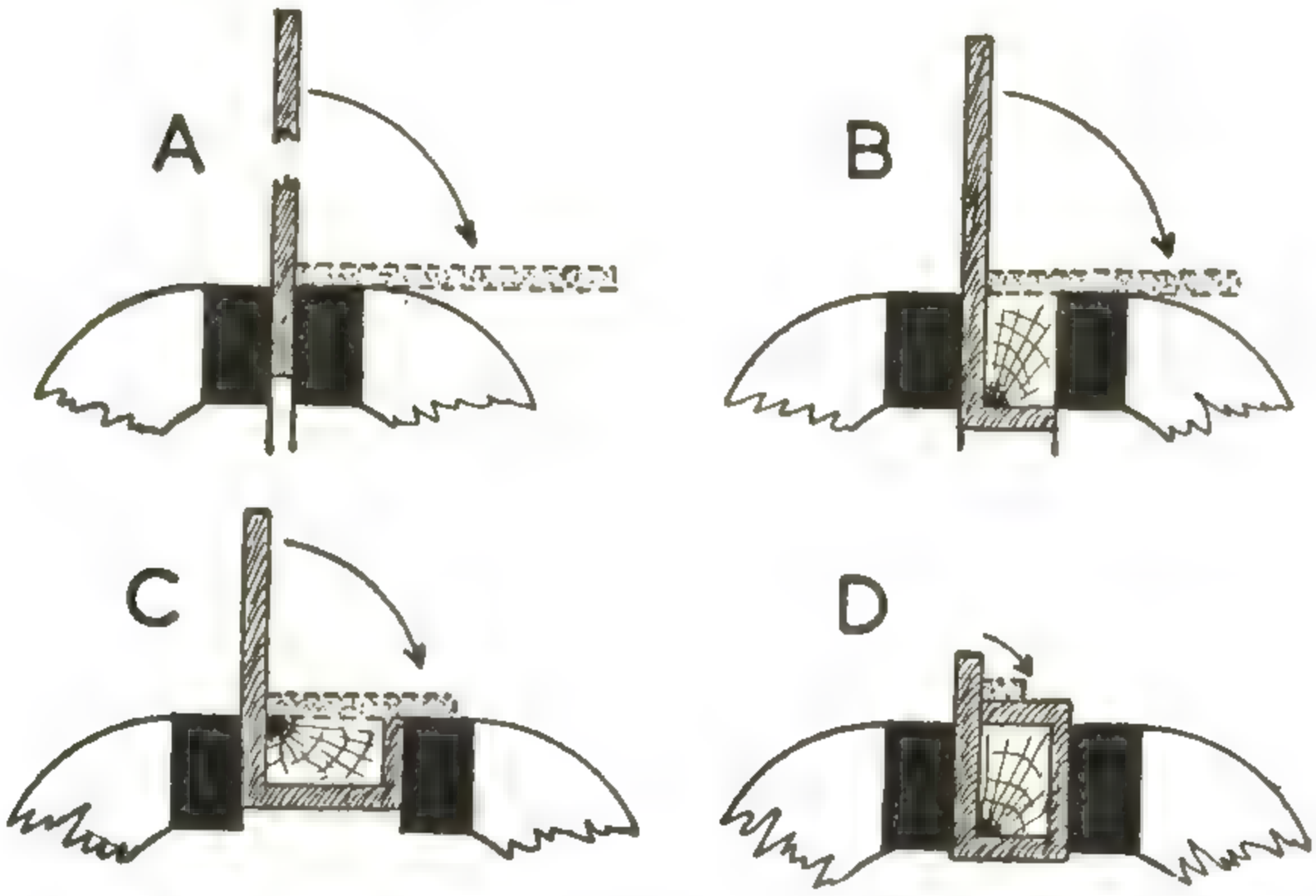


Fig. 4

soldered into place at the end of the tube after the internal sliding armature assembly has been made and placed within the body-tube.

The bending of the sheet into a tube should be done by working the metal around a wooden or metal block the size of which is $\frac{1}{2}$ in. $\times$ $\frac{1}{4}$ in. less twice the thickness of the sheet metal being used, in each direction. The block should be held firmly in the vice, and each successive bend dressed up truly square with a hammer (Fig. 4), so that a perfectly-shaped tube is formed and appears as shown in Fig. 5. A square or round hole should be cut where shown at *X* (Fig. 2) to allow for inspection and lubrication of the cross-slide slot and pin. The longitudinal seam shown in Fig. 5 is then carefully soldered, and one slotted end bent down into place to close one end of the tube.

Next, the armature slide is built up from brass strip of fairly stout gauge (about $\frac{1}{16}$ in. thick), and of a length equivalent to the length of the tube plus twice the stroke of the armature. This will be about 3 in. long. Near each end of this brass slider is wrapped round a piece of " tin-

plate " (perhaps cut from a domestic tin) which does duty as the armature proper, one or the other piece being pulled into the field of whichever solenoid coil is energised. It will be found best not to trust to a friction grip for the tin-plate round the brass slider, but to solder lightly where shown in Fig. 6.

It will be found best to cut the " z "-shaped slot in the slide-bar before fixing the armature bars in place, and

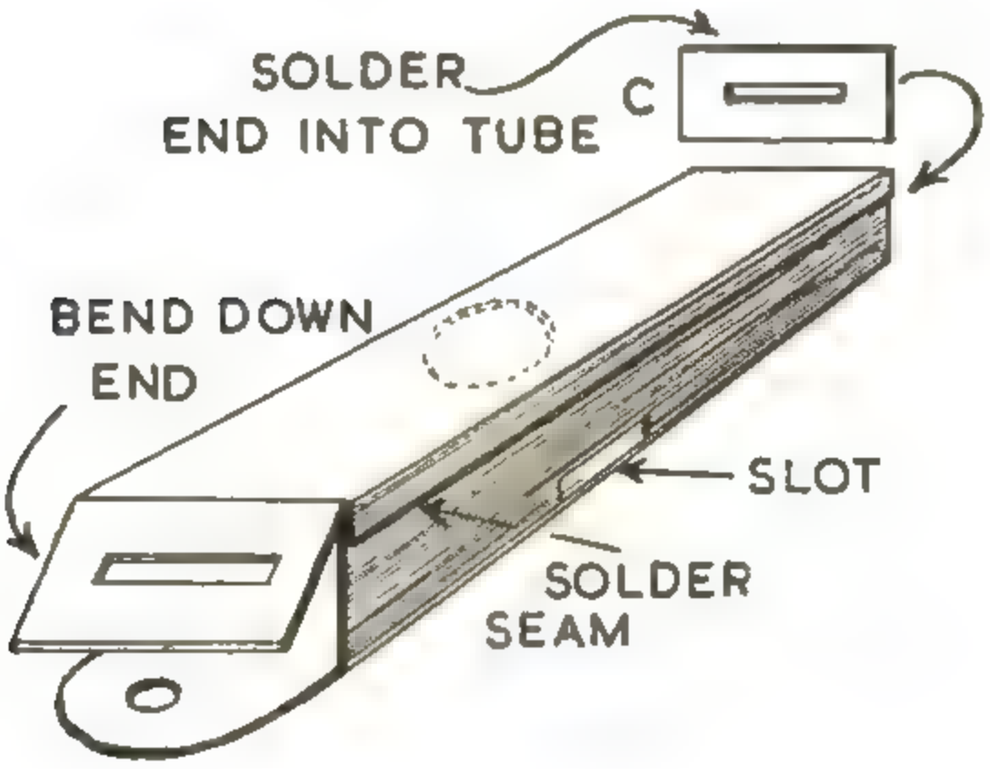


Fig. 5

care must be taken to see that the throw allowed is *very* slightly greater than the stroke required to operate the point. In " O " gauge this will be about $\frac{1}{4}$ in., and in " OO " about $\frac{1}{8}$ in., but individual points differ in their throws very considerably, and it is a good plan to check up before scribing and cutting the slot with drill and needle-file. The greatest care should be exercised to ensure that the corners *C, C* are nicely rounded, so that the pin in the cross-slide does not jamb as it traverses them.

The armature slide may now be tried in the tube, and any clearances made in the end slots to ensure that it moves freely to and fro ; keeping the slider centrally disposed in the axis of the tube. If all is well, it can be temporarily withdrawn, and the cross-slide made up as shown in Fig. 7. A hole should be drilled at each end to take the point-rod, and a 6-B.A. tapping hole made in the

centre which should be tapped 6-B.A. into which the drive-pin is subsequently screwed.

After trying the cross-slide in its bearing slots and ensuring a smooth fit, the main slide should be re-inserted in the tube, and the tapped hole in the cross-slide lined up with the " z "-shaped hole in the main slide; the drive-pin is then screwed into place through the inspection-hole in the tube. The other end plate bearing of the main slide (*C*) is now slipped into place over the projecting end of the main slide and carefully soldered into place.

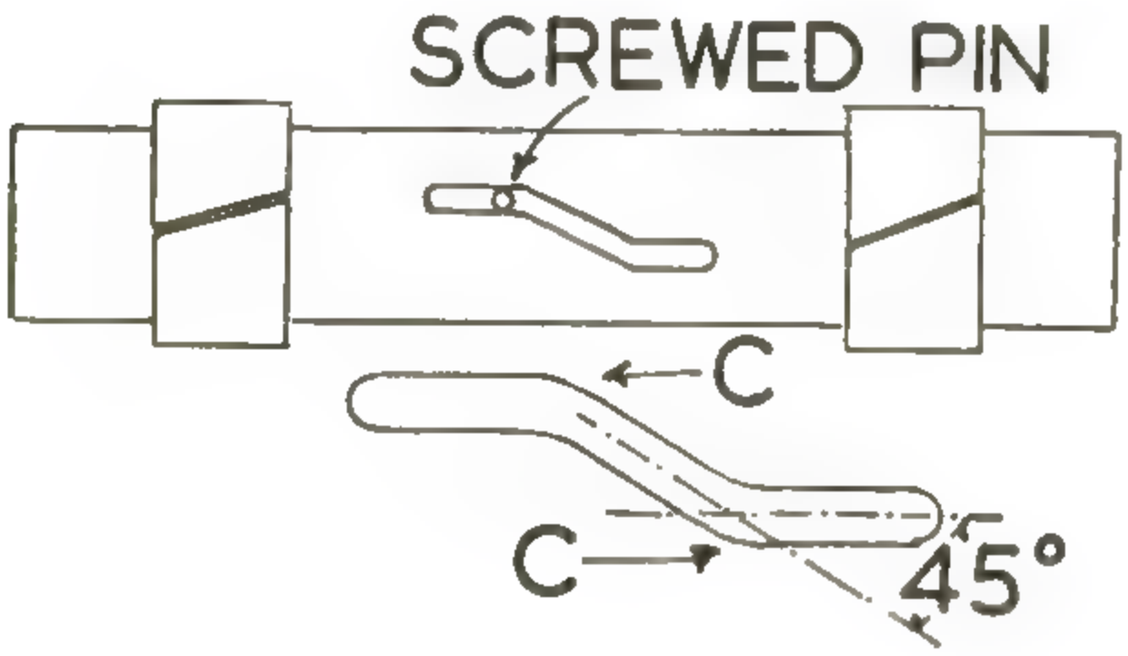


Fig. 6

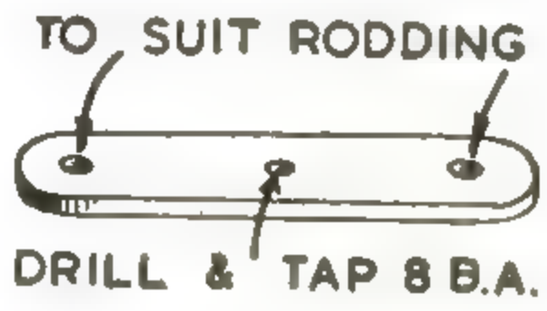


Fig. 7

On pushing the armature slider to and fro the cross-slide should move transversely the correct amount of its predetermined stroke, and be effectively locked into either position by the upper and lower portions of the " z." A certain amount of lubrication of the slots and pin will be needed, as also will a little " running in," after which all excess oil should be removed, and a start made on the winding of the solenoid coils.

These are in no way difficult to wind or connect, being made with No. 24 or 26 s.w.g. double-cotton-covered copper wire, of which, if No. 26 is used, 36 turns will be accommodated in the $\frac{3}{4}$ in. of tube at each end. (Shown shaded in Fig. 2). Six layers, comprising some 200 turns in all, will be needed as the very minimum; but if more layers can be wound neatly in place without the turns slipping, so much the better, for the number of turns is

more important than the gauge of the wire used. A compromise has to be made in this respect to enable the number of turns of a sufficiently large gauge of wire to carry the current to be accommodated within the confines of the solenoid tube. No. 24 or 26 s.w.g. is, for this reason, the best all-round choice, but there is no need to be meticulous as to gauge of wire used.

There is no need to worry, either, over the direction in which the windings are made. They can be right or left-handed without jeopardising the correct functioning of the motor.

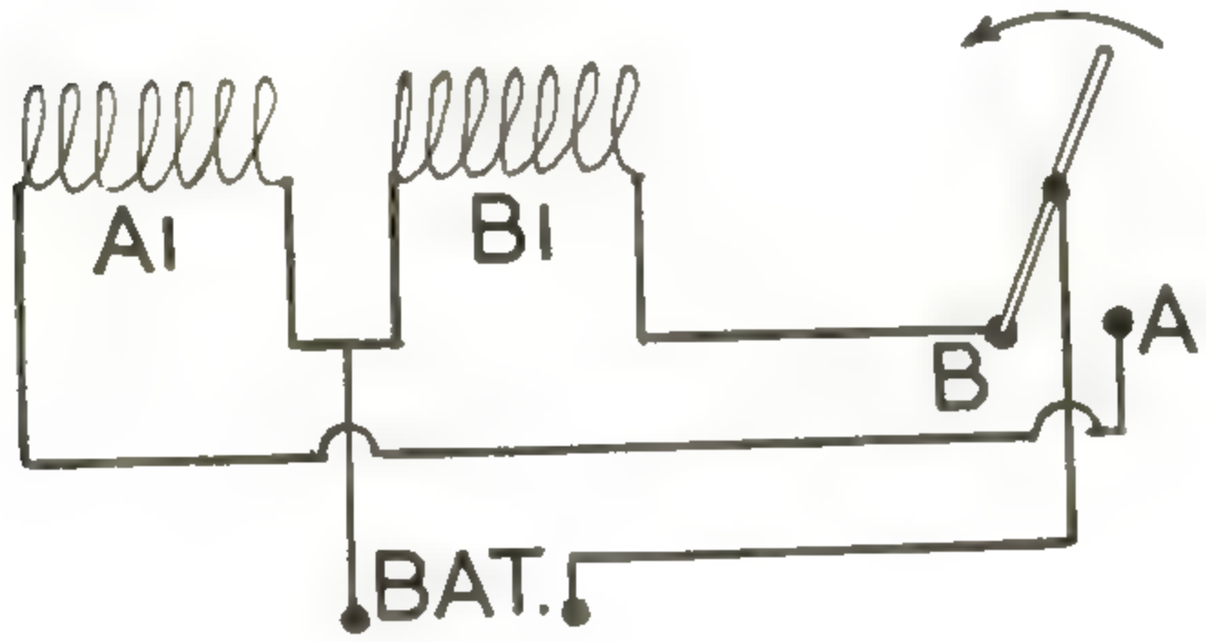


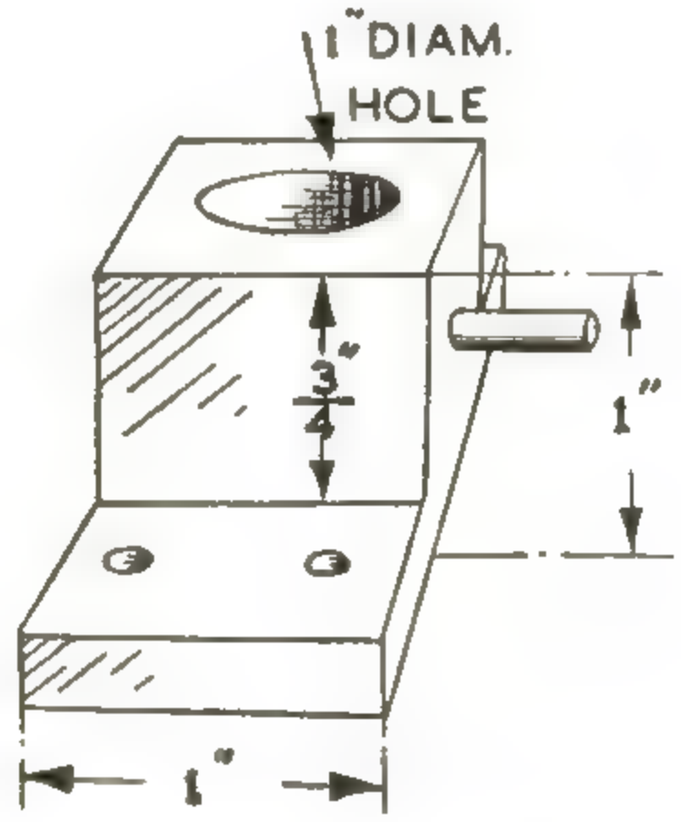
Fig. 8

As to the wiring up of the unit into a lever-frame, a glance at Fig. 8 will show that this is quite simple. The two inner ends of the coils are joined together and taken direct to the power supply, the latter being also taken to to the centre pin of the lever or lever-frame. A wire is then connected between each free end of the coils and the appropriate wiping contact of the lever. In this respect, it is important to remember that the wiping contacts on the levers must never be of the "positive" or "continuous" kind, but must be so arranged that the lever contacts one or the other as it passes from the "rest" to "pulled" position—or *vice versa*. This arrangement is to ensure that there is no continuous flow of current through the solenoid coils after the points have been moved, for if there were, the solenoid coils would speedily be burnt out and rendered useless. In either the "rest" or "pulled"

position, the lever must not be contacting the lead to either solenoid coil. It must only touch them as it is moved from one position to the other. This is important.

Little point-motors made in the way described—or with any slight modification, the reader may see fit to embody—will be found to give enduring service with little or no attention other than occasional oiling. They are simple to make, and there is nothing to get out of order in the moving parts. They are, withal, self-locking and positive in their action.

Fig. 9



For those who are not in favour of the use of electricity for subsidiary purposes on a model railway, here is a description of a simply-made pneumatic point-motor and impeller, which may be made from a few pieces of hard-wood and a scrap of kid or wash-leather at a really negligible outlay.

The general idea of the use of air (or vacuum) for the operation of points and signals—both prototype and model—is by no means new; but, as has already been mentioned, the earlier model methods involved rather fine machining limits because regular pistons and cylinders were used for both the impeller (at the lever-frame) and the motor (at the points or signals). By the introduction of a diaphragm-type impeller and motor, the construction becomes so simplified that little more than a coping-saw, a

tube of Seccotine, and the simplest of raw materials are required to produce a dozen or so thoroughly reliable pneumatically operated motors—the signals and points, of course, being ready to hand.

In Fig. 9 is depicted the general scheme of the diaphragm motor used, and it will be seen that the body of the unit consists of a wooden block 1 in. × 1 in. × 1½ in., in the centre of which is drilled (with an Irwin wood-bit) a 1-in. hole which passes only half-way through the depth of the block (see Fig. 10). Two fixing lugs or ears are left at

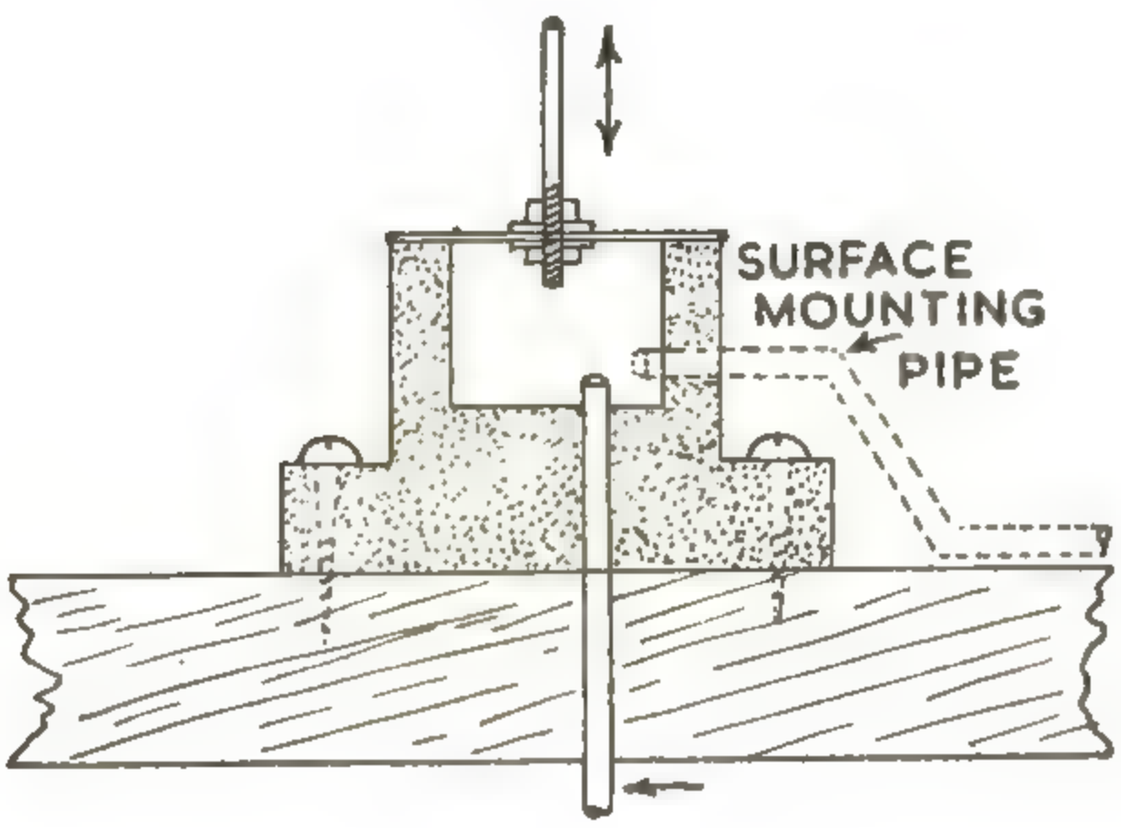


Fig. 10

opposite sides of the bottom of the block for screwing it down to the railway baseboard. The block is cut from solid hardwood, such as oak or mahogany. If the making of a number of motors is contemplated, it will be found an advantage to shape up a long strip of wood as shown in Fig. 12, wherein the 1-in. holes and fixing holes may be drilled before cutting it up into individual units.

After all drilling has been done, the units should be well sandpapered all over—particularly inside the large holes and treated to two coats of good shellac varnish. Alternatively, three or four coats of ordinary French polish may be used, the purpose of the coating being to render the pores of the wood impenetrable by air.

Next, some 1½-in. squares of kid or wash-leather are

pierced through in the centre with a large knitting-needle, so that a clean hole is made of sufficient size to pass an 8-B.A. screw. A 1-in. length of 8-B.A. brass studding is then passed through the hole and the leather disc tightly

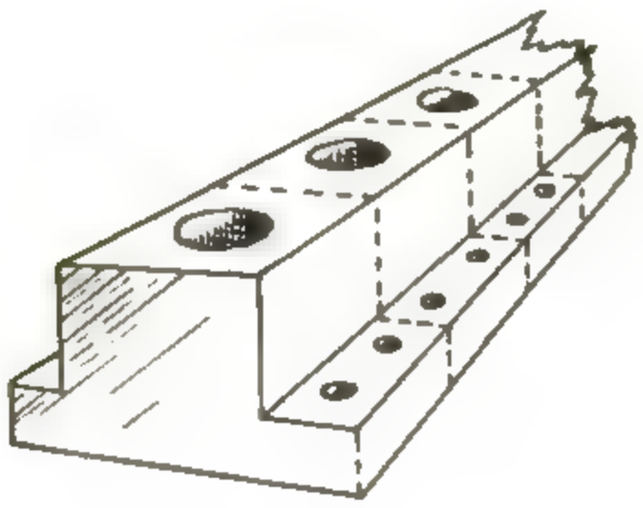


Fig. 11

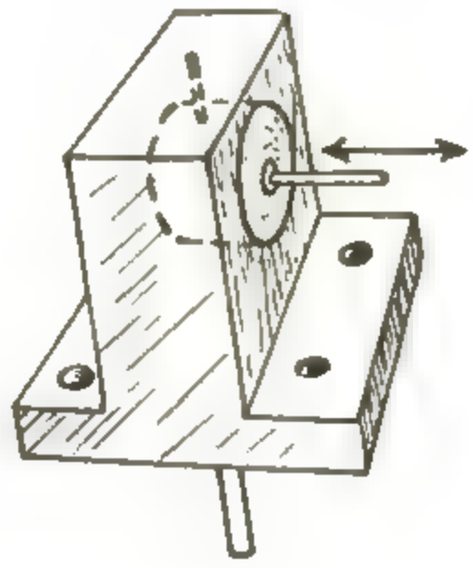


Fig. 12

screwed to one end of the studding; washers being interposed between the nuts and the leather to ensure that the latter is not damaged, and that an air-tight joint is made.

Alternatively, the motor blocks may be cut as shown in Fig. 12, so that the thrust of the diaphragm is horizontal instead of vertical. In both types, however, the inlet to the chamber must be allowed to pass through the block by way of a $\frac{1}{8}$-in. hole, into which a short length of $\frac{1}{8}$-in. brass tubing should be forced after being smeared with Seccotine.

The construction of the impeller diaphragms for use at the lever-frame end of the connecting tube is exactly similar, except that the lower end of the lever is connected to the 8-B.A. rod fixed to the centre of the diaphragm, the unit being arranged on its side (as in Fig. 12). The leather of the impeller diaphragm should be mounted rather slacker than that of the motor, to accommodate the longer stroke of the levers. (See Fig. 13).

It may be found necessary, particularly in the case of very long runs of connecting tubing, to pierce a very fine "bleeder" hole as shown in Fig. 12. So that a certain amount of pressure-equalisation takes place

which will prevent both diaphragms getting set in a collapsed position.

The connecting tubing between the frame and the motor units can consist of $\frac{1}{8}$-in. brass tubing—as used for gas "switches," or of cycle valve-rubber tubing, the latter being by far the cheaper and more readily obtainable.

Should it be found that the kid or chamois leather used for the diaphragms is not air-tight, a good soaking in light oil (such as "Oilit") will immediately cure the fault permanently; as well as making the leather more

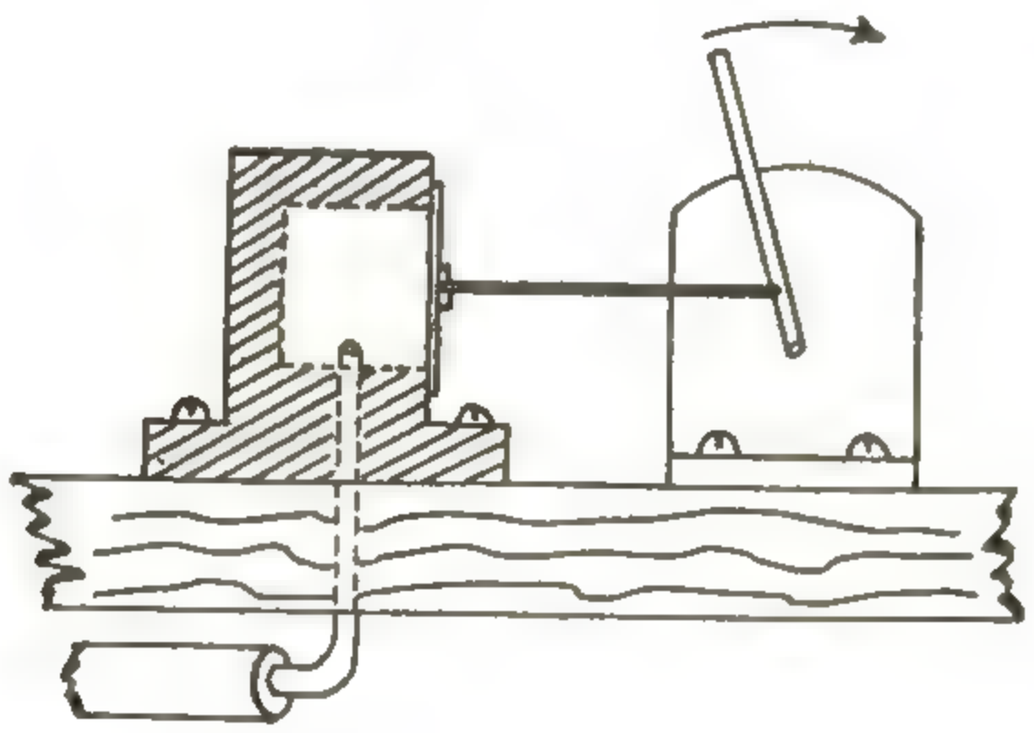


Fig. 13

supple. Needless to say, the oiling should be done *after* the diaphragm has been stuck down on top of the "cylinder" block; if it is done previously, the leather cannot be stuck by any manner of means.

In rigging points for pneumatic operation, it must always be remembered that nothing involving the bending of solid switch-rails at the blades can be considered. The tongues of the points require to be pivoted so that they move quite easily, as also is incidentally the case with solenoid-operated gear.

In the earlier piston-type pneumatic systems, the reliability of action was very easily impaired by the presence of grit in the cylinders, as well as by the lack of correct and timely lubrication. In the diaphragm type described, neither of these shortcomings is apparent.

As to the method upon which the pneumatic system

works, the impeller diaphragm at the lever-frame either compresses the air in the motor cylinder, or, on its return stroke, creates a partial vacuum therein, thereby causing the motor diaphragm to move in and out in sympathy with the impeller.

It is advisable to construct the impeller units of a slightly larger size (i.e, with a larger hole) than that of the motors, so that any slight line leakage in transmission which must inevitably occur can be made up for at each stroke. If the impellers are of greater cubic capacity than the motors, the deliberately enforced leakage at each stroke will be found an advantage; it being largely accommodated by a slight expansion of the rubber transmission line.

It is interesting to note that "OO" gauge points have been worked with the foregoing simply-constructed apparatus up to a distance of 35 ft., but the limit has yet to be determined by experiment.

The main feature in using air for power transmission to points and signals on models is, of course, the total elimination of all the frail apparatus associated with their mechanical operation, together with the troublesome adjustments so continually necessary to maintain the latter method in perfect working order. Pneumatic operation is truly simplicity itself—both in construction and upkeep, and if reasonable care is used in making units, success is assured.

The construction of electro-magnetic motors for the operation of model signals is a much simpler matter than that already described for point motors, by reason of the fact that a one-way action only is required, the return motion of the semaphore to the "on" position being brought about by the counterbalance weight on the signal post. There are two distinct types of winding for the solenoid motors used on a model railway. One, which is capable of carrying a large current for extremely short periods, and the other which will handle small currents for a long time without getting overheated. The first

type is that used for point motors, and the second is designed for light work, such as semaphore arm and relay operation.

It will be understood that, if the current consumption over a protracted period is to be low, then the internal resistance of the solenoid coil must be proportionately high, so that only a little current passes. Supposing the

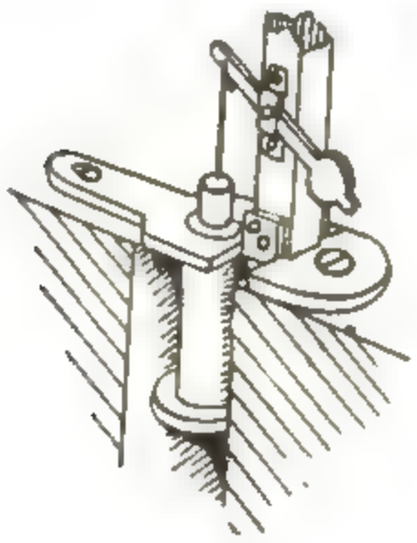


Fig. 14

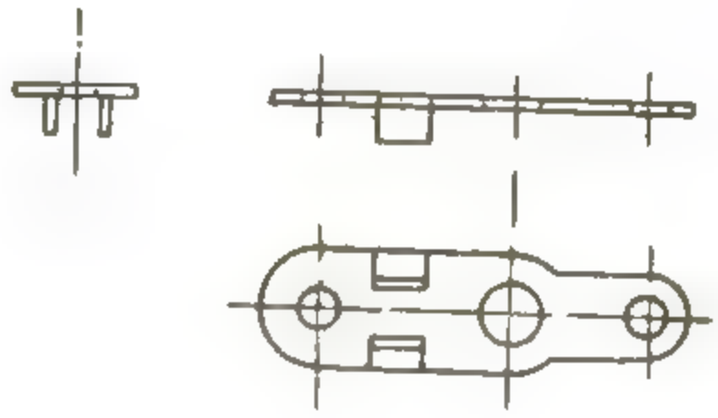


Fig. 15

supply voltage is six volts, then the coil—if it is not to get overheated—must not pass more than about $\frac{1}{4}$ ampere at that voltage, and this will require a coil with a resistance of about 30 ohms. An amount of wire of sufficient size to give this resistance and at the same time capable of passing $\frac{1}{4}$ ampere has to be accommodated within the confines of a sensibly-sized solenoid bobbin. The wire must also be of ample gauge to carry the amperage without undue overheating of the coil. Approximately 30 yards of No. 38 s.w.g. enamelled wire will be found to fulfil the requirement, and this amount can be easily accommodated on a bobbin 1 in. long by $\frac{7}{8}$ in. in diameter inside the cheeks. If less current is desired to be passed, either the next smaller gauge of wire (No. 40) should be used, or the diameter of the bobbin should be increased, and more turns wound thereon. Conversely, more current will be passed by thicker wire or fewer turns.

The making of a simple bobbin hardly needs description, the sketch (Fig. 14) showing all the salient features. It will be seen that the wire is wound on a circular bobbin which may be made up wholly from brass, or by cementing

Tufnol or $\frac{1}{8}$-in. plastic discs or washers to a short length of tubing, because the whole bobbin must be built of non-magnetic materials.

By making the top cheek of the bobbin of brass, and of the shape shown, it is possible to arrange for the mounting of both the solenoid and the signal it operates by screwing the whole assembly to the baseboard as shown, a 1-in. hole being drilled through the latter to receive the bobbin.

There are two simple methods of coupling a solenoid motor to work a signal arm; one operating on a " pull down " principle (Fig. 14), and the other on a " pull up " arrangement (Fig. 16). In the first type the counter-balance weight is balanced against the weight of the solenoid armature, whereas in the latter it need be only a dummy; the armature itself acting as a counter-weight to the arm. Owing to the ineffectiveness of the very light and small counterbalance weights associated with scale " OO " signals, the second type of drive is much to be

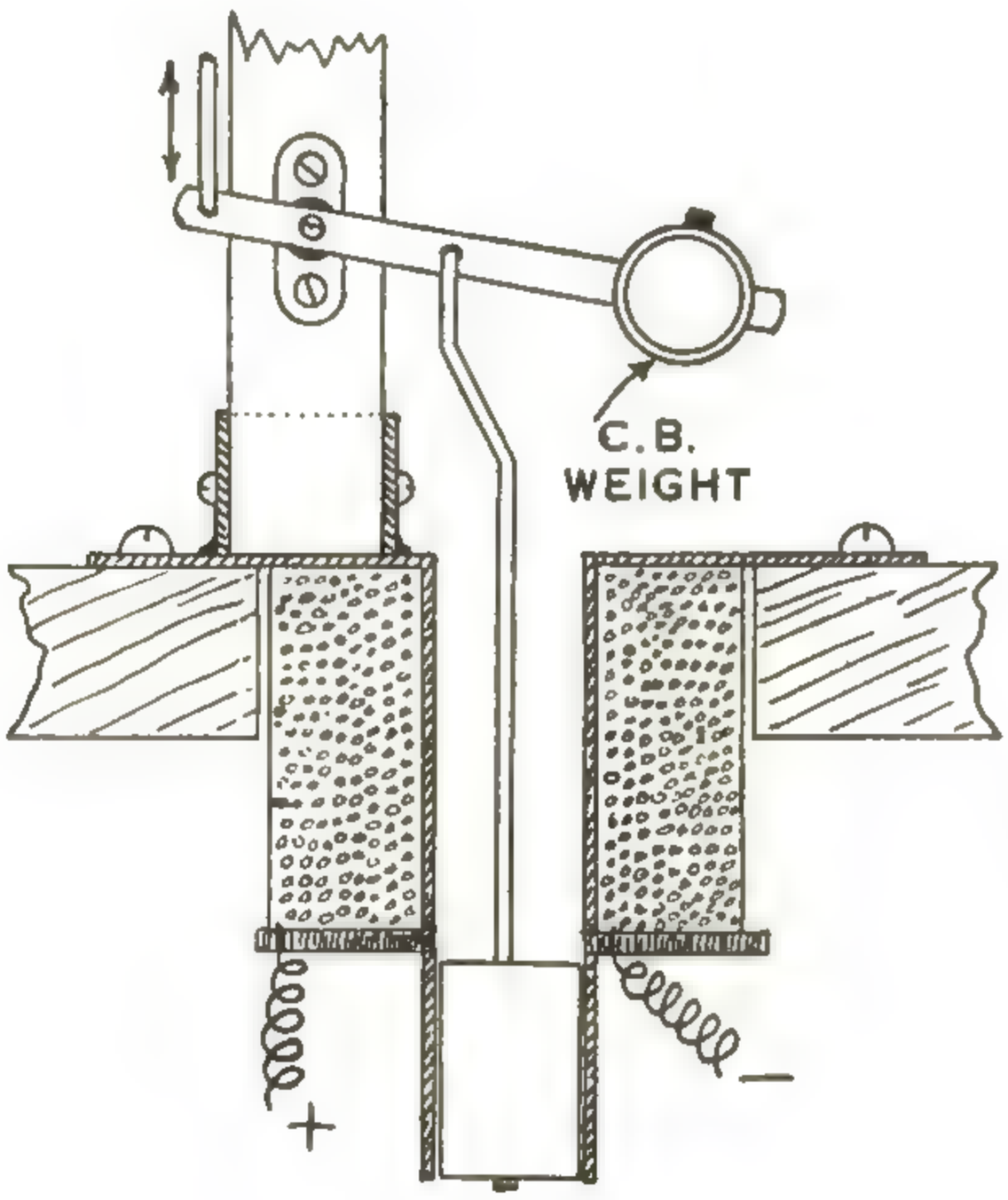


Fig. 16

preferred in that scale, the visible counter-weights being made of cardboard.

Having discussed the simple means by which the model railwayman can build his own point and signal motors, the manner in which they can be applied in their correct positions on a layout and operated in true prototype manner will now be discussed. It must be understood in this respect that signals are not to be promiscously scattered about a layout with no attention to their correct usage and positioning, and in this matter the reader is referred to another work of the writer's dealing exclusively with this particular side of signalling.*

For simple "block" signalling, in cases where the signal sections are but little longer than maximum train-length, the basic circuit shown in Fig. 17 will be found quite adequate if solenoid motors are used. Unfortunately, pneumatic signalling does not in any way lend itself to

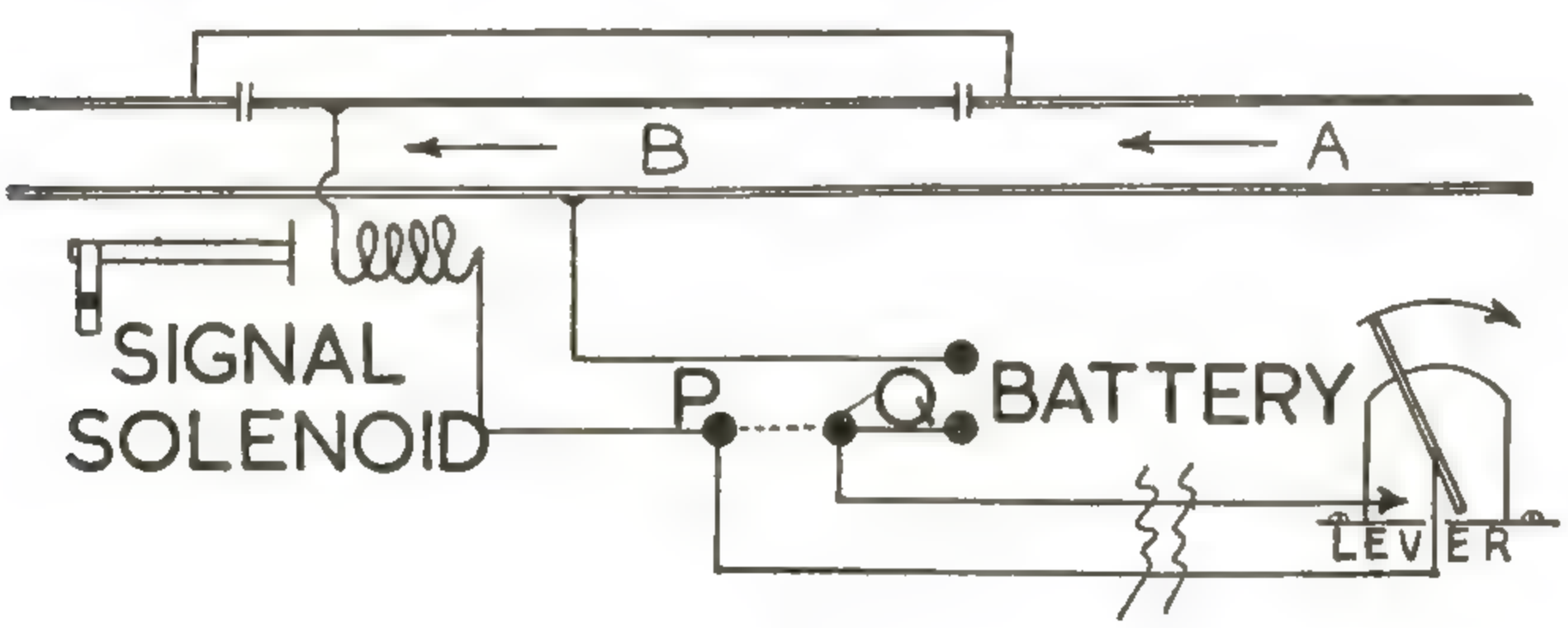


Fig. 17

automatic operation without the introduction of numerous complications of electro-pneumatic relays which are not successful in model form.

It will be noticed in Fig. 17 that the automatic lowering (or raising, in upper-quadrant arms) of the signal arm is effected by the entry of the first vehicle in a train into

* *Model Railway Signals*, Messrs. Percival Marshall Ltd.

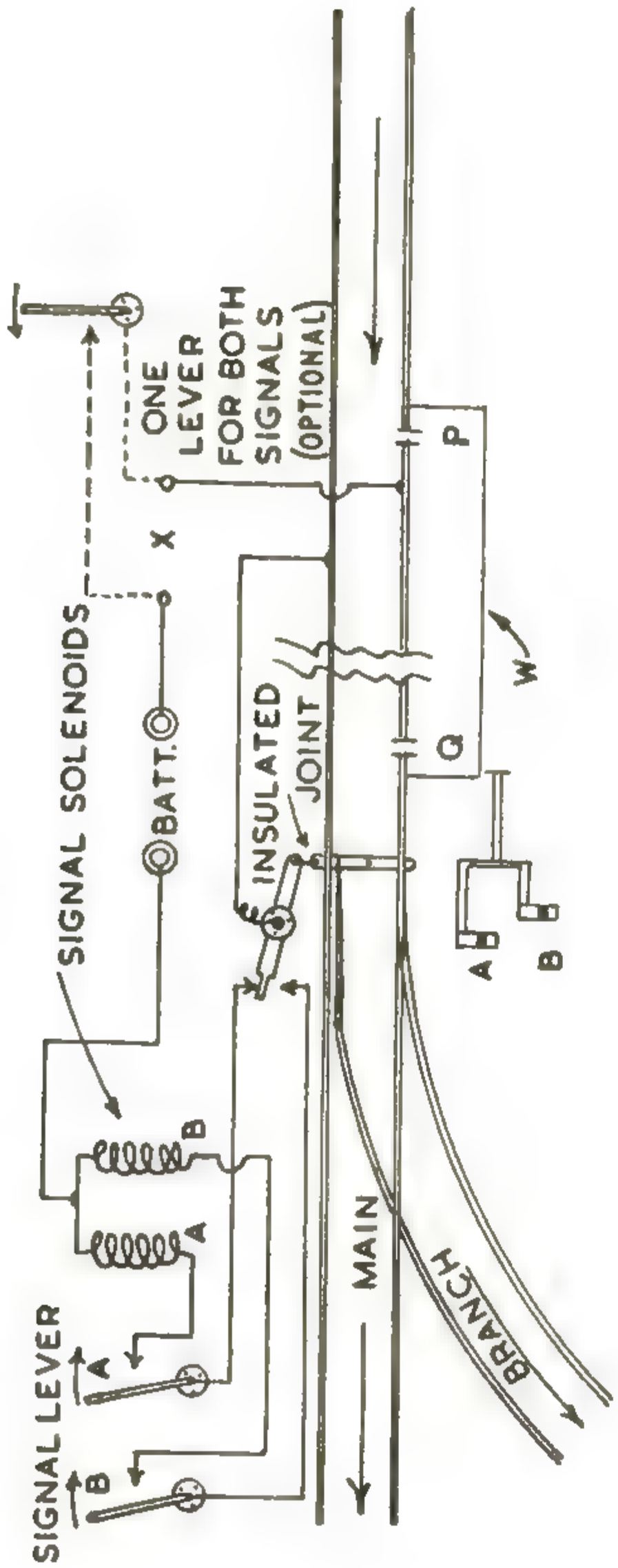


Fig. 18

the section, the operating current passing from one running-rail to the other *via* the wheels and axles of the vehicles. On the last vehicle clearing the section, the signal arm will return to the "on" position by reason of the flow of current being broken.

In the case of the facing single-line junction depicted in Fig. 18, it will be seen how either the main-line or branch line signal is pulled "off" according to the direction in

which the points are set; the selection of arm being controlled by a small and easily-made wiping switch fitted either to the tail-rod of the point-stretcher or directly in the signal-box lever-frame. In point of fact, there is little to choose between these two positions for the fitting of appropriate contacts for electrical selection or interlocking, though it may be said that if it is carried out at the track side, there is not the possibility of the wiring getting so complicated as would be the case at the lever-frame.

The arrangement at the splitting signal of Fig. 18

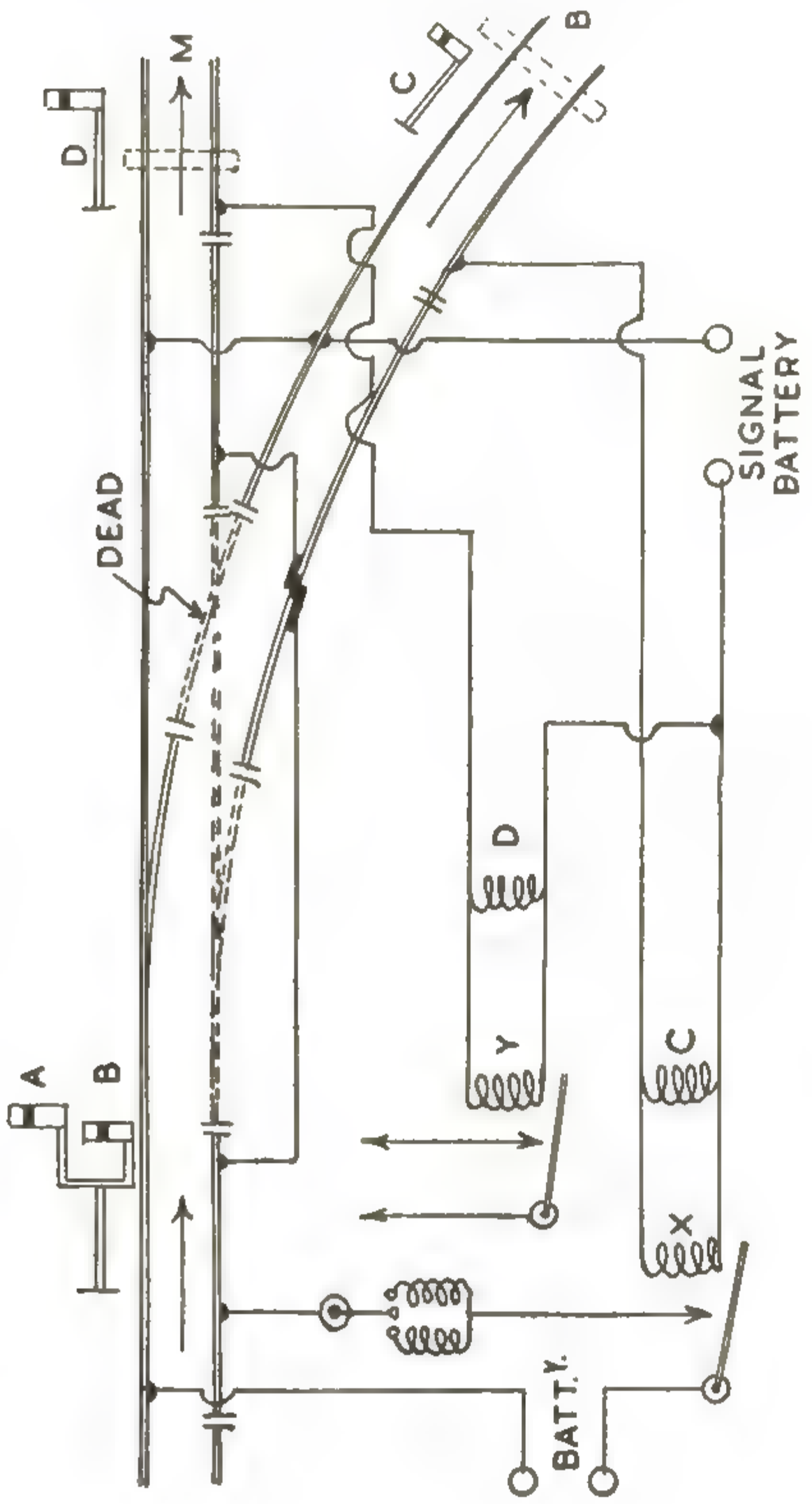


Fig. 19

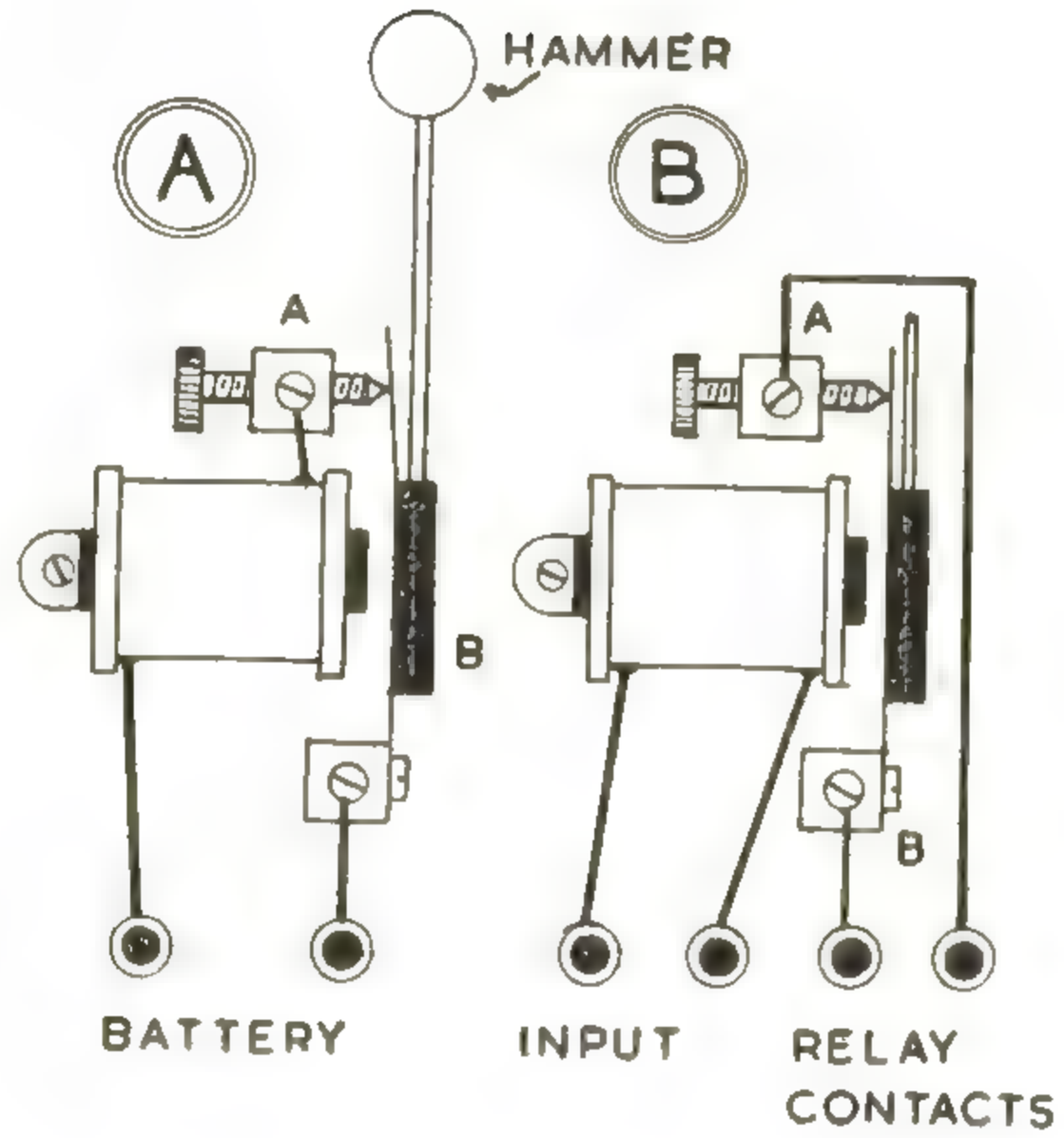


Fig. 20

may be said to be electro-mechanical and semi-automatic, being worked by the oncoming traffic regardless of whether the line ahead—on either branch or main is clear and unoccupied; but if it is desired to make this provision, it will be necessary to arrange things so that the presence of a train or detached vehicle on the section of track ahead will automatically intercept the flow of current through the track and wheels of the approaching train. This can only be done by the inclusion of another circuit which is linked with the first by means of a relay as shown in Fig. 19.

In this circuit it will be seen that a vehicle or train standing on either the main-line at *M*, or the branch-line at *B*, will not only cause either signal *C* or *D* to assume the "off" position, but will also, through the medium of one or other of the relay coils *X* or *Y*, cause the splitting-signal operating circuit to be broken and inoperative, so that only the appropriate signal *A* or *B* can go "off," according to which line is clear.

The relays *X* and *Y* can be readily produced by conversion of an ordinary cheap electric bell, the bobbin of

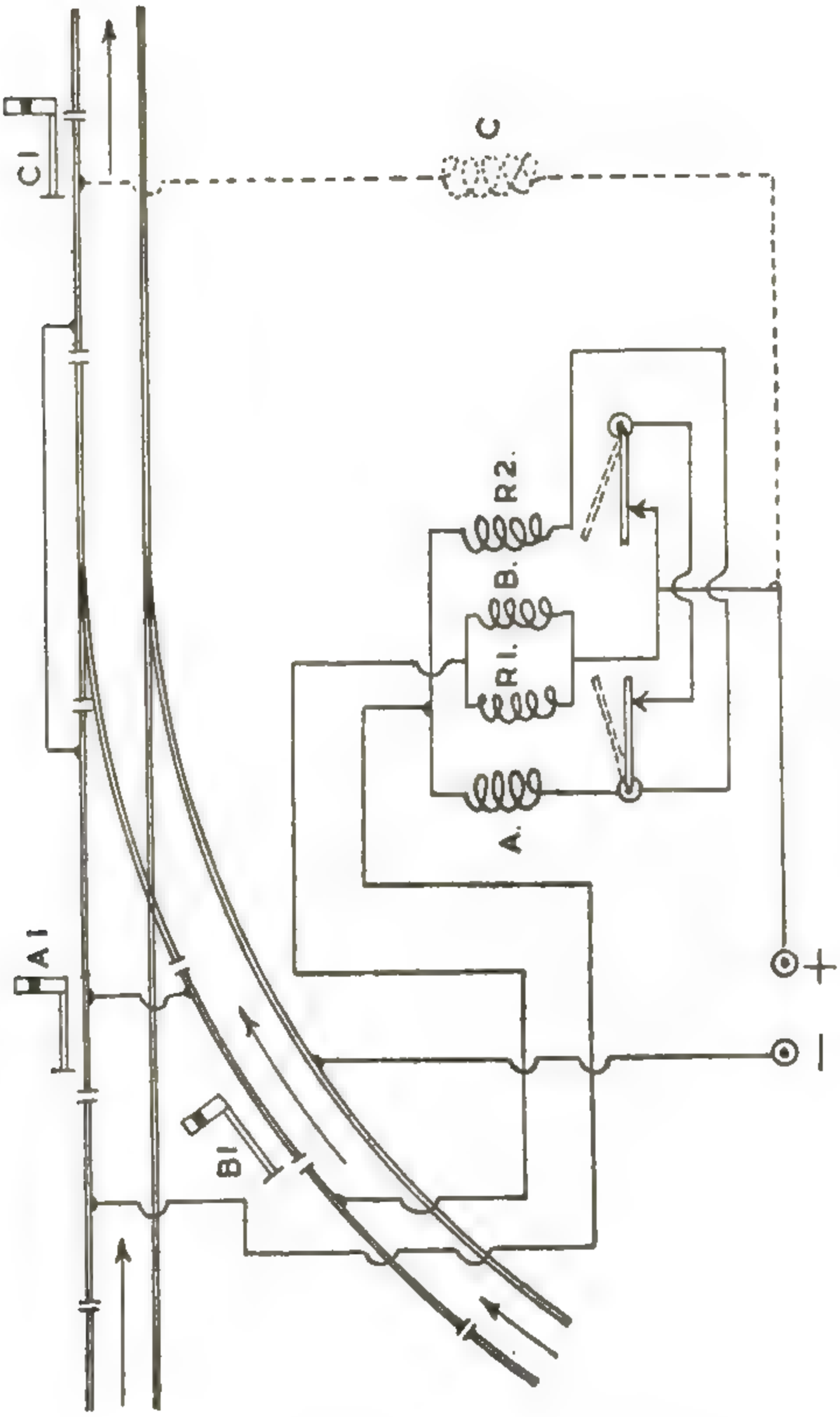


Fig. 21

which must of necessity be rewound with the same gauge and length of wire as a standard signal solenoid. Such bells can be very cheaply purchased, and they must be rewired as shown in Fig. 20 ; in which *A* represents the original wiring, and *B* the modification to produce a relay.

Trailing single-line junctions can be rendered interesting from a spectacular point of view by arranging that the approach of a train from one direction not only clears its *own* signal, but prevents a train on the other line from

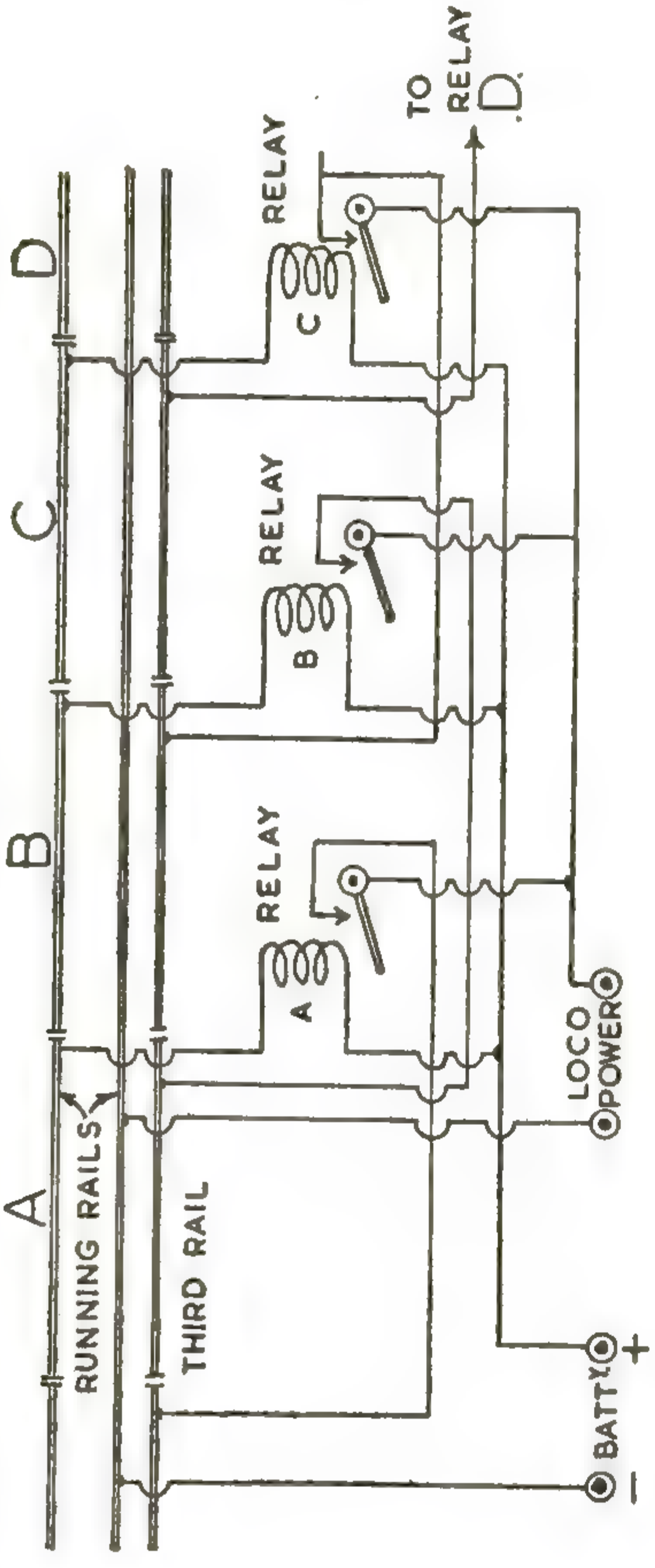


Fig. 22

clearing its signal; and although this will not obviate the risk of a collision at the converging point, it will, at least give the " driver " of the second train an adverse indication.

Such a circuit is shown in Fig. 21, where *A*, *B* and *C* are the solenoid motors operating signals *A*1, *B*1 and *C*1

respectively, $R1$ and $R2$ being the " bell " type relays in parallel with A and B coils.

It must, however, be understood that the circuits of Figs. 19 and 21 do not give positive protection of the junction by cutting the power-supply to the locomotives, but only afford a measure of accurate signal indications according to the trains on the lines; without a point *cum* signal to locomotive power interlock, such foolproof protection is impossible.

The relative usefulness of fully automatic signal/locomotive power interlocking was noticed in the last chapter, and though, as pointed out, there is little to be said for the system, a *resume* will now be given of its salient points together with some simple signal/power interlocking circuits which may form a basis upon which the reader can elaborate a system for his own especial layout if he so desires.

Basically, the principle consists of the use of back-coupled relays, as shown in Fig. 22, wherein the presence of a vehicle in the next section (or the section but one ahead, if the layout is an extensive one) cuts out the locomotive power-supply to the section in the rear (or the section but one in the rear); thus effectively preventing all train movements into the occupied section (or into the empty section between the trains—as the case may be).

Power/signal interlocking of this nature may be superimposed quite easily upon either of the circuits, Figs. 19 or 21, provided that the secondary contacts of the relays (Fig. 22) are of sufficient size to carry the current taken by the locomotive motors. The wires to these contacts must also be of ample size—No. 18 s.w.g. being quite satisfactory for the purpose. If wires of smaller gauge are used, the engines will go slowly and not give their rated power output.

At facing or trailing junctions, power may be interlocked in precisely the same way as that already shown for signals in Figs. 19 and 21, heavier contacts being substituted on

the relays, and the wires from them taken to the locomotive power-supply instead of to the signals. In cases in which it is desired to operate signals and power interlock, two separate sets of contacts must be used on each relay—one

Fig. 23

pair for the signals and the other for the locomotive power-supply. Such relays can often be purchased as war disposals material, and are very well-made and effective. (Fig. 23).

CHAPTER THREE

BRIEF mention has already been made of the various possible sources of power for working electrical points and signals, but it will be necessary to delve a little deeper into the subject with a view to explaining the alternative methods which can be used, and the wiring and general technique necessary to use them.

If an a.c. to d.c. mains unit is already in use to supply the traction current for the layout, it is quite a simple matter to draw the signal and point motor power from the pair of auxiliary terminals usually to be found on the unit. The very obvious drawback is, however, that the supply at these terminals is usually alternating low-voltage, the disadvantages of which have already been pointed out.

Fortunately, it is easily possible to convert this a.c. supply to d.c. by the interposition of a small rectifier cell, and in Figs. 24, 25 and 26 are shown three ways of wiring rectifier cells so that a low-voltage a.c. output from a transformer is converted into d.c. at a slightly lower voltage.

Standard rectifier cells are readily obtainable from most radio supply stores, and they should be selected of such a current-carrying capacity that any contemplated signal scheme will be provided with sufficient current. On the average layout, $\frac{3}{4}$ to 1 ampere rectifier cells will provide such a supply with ease, as usually not more than two, or at the most three signal motors are ever in use at the same time.

The simplest rectifying circuit is shown in Fig. 24, in

which but one cell is used, thus only providing what is known as "half-wave" rectification; and having the disadvantage of causing electro-magnetic apparatus fed with current rectified by its use to hum in a rather objectionable manner with the 50-cycle note of the house-mains. By adopting the circuit shown in Fig. 25, which uses two rectifying cells, "full-wave" rectification is effected which gives a flow of d.c. twice as steady as does the half-wave system, and which does not produce such a pronounced hum in the apparatus it supplies.

Fig. 24

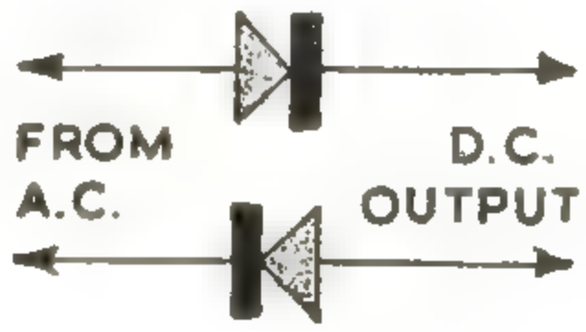


Fig. 25

In Fig. 26 is shown the circuit necessary to produce "bridge" rectification, which involves the use of four cells, wired as indicated. Sometimes cells can be bought in pairs or in "fours," ready wired in this manner, as ex-army or R.A.F. surplus, and advertisements in *The Model Engineer* will often reveal the supply houses marketing such material.

Fully 75 per cent. of the ripple which causes the humming noise may be effectively smoothed out of the d.c. output from a rectifier by the incorporation of suitable condensers and chokes, as depicted in Fig. 27, where two 25 V × 50 mfd. radio "cathode bias" condensers are used for smoothing purposes, and the primary winding of an old radio "output transformer" is used as a choke. In Fig. 28, a more perfect form of smoothing is shown, where three 25 V × 50 mfd. condensers are used, together with two chokes. In each of these circuits, care must be taken

to observe the polarity of the condensers, each end of which will be found clearly marked with a " plus " and a " minus " (positive and negative). These must be connected to the positive and negative terminal of the d.c. output in every case.*

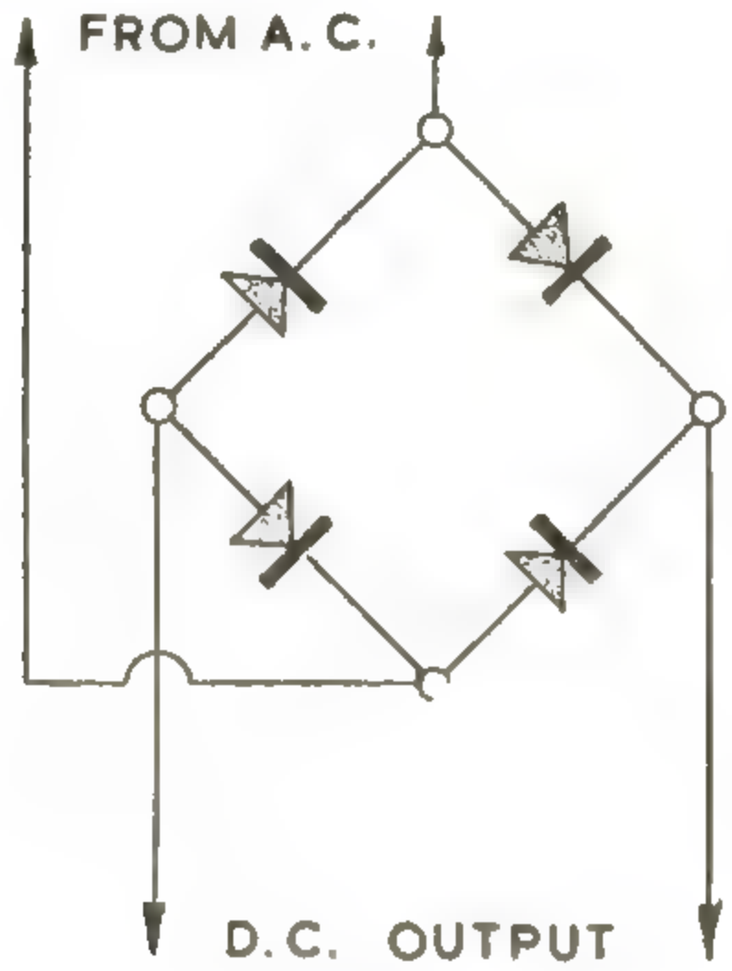


Fig. 26

The circuit of Fig. 28 gives an almost perfect hum elimination; but if still further perfection in this direction is required, 500 mfd. × 12 V electrolytic condensers may be used in place of those mentioned, though these are much more expensive and not so readily obtainable. Incidentally, the latter type are effective in removing every trace of hum from the traction motors of locomotives fed *via* an a.c. to d.c. rectifier unit; but for this purpose they must be of the " reversible " type to allow for the use of split-polarity and locomotive reversing polarity. They are generally incorporated as standard on locomotive power units available in the U.S.A.

* The polarity of the d.c. output can be found quite easily by dipping a sheet of blotting-paper into a strong solution of cooking salt. If the paper is connected to the positive pole of the output, a greenish colouration will be produced on the wet paper, whilst the negative pole will produce no such effect. Alternatively, red litmus paper may be used, also moistened with salt water. In this case a blue stain will be apparent at the negative pole when both poles are touched on the wet paper.

By combining the rectifier units of Figs. 24, 25 or 26 with the smoothing units of Figs. 27 or 28, a really satisfactory power-supply can be produced for signal or point operation, the step-down from house-mains voltage to that used on the layout signalling being accomplished by an auxiliary secondary winding on the mains transformer in the traction power-supply rectifier unit, as shown in the circuit of Fig. 29. There are, however, one or two important matters to be considered when using the auxiliary

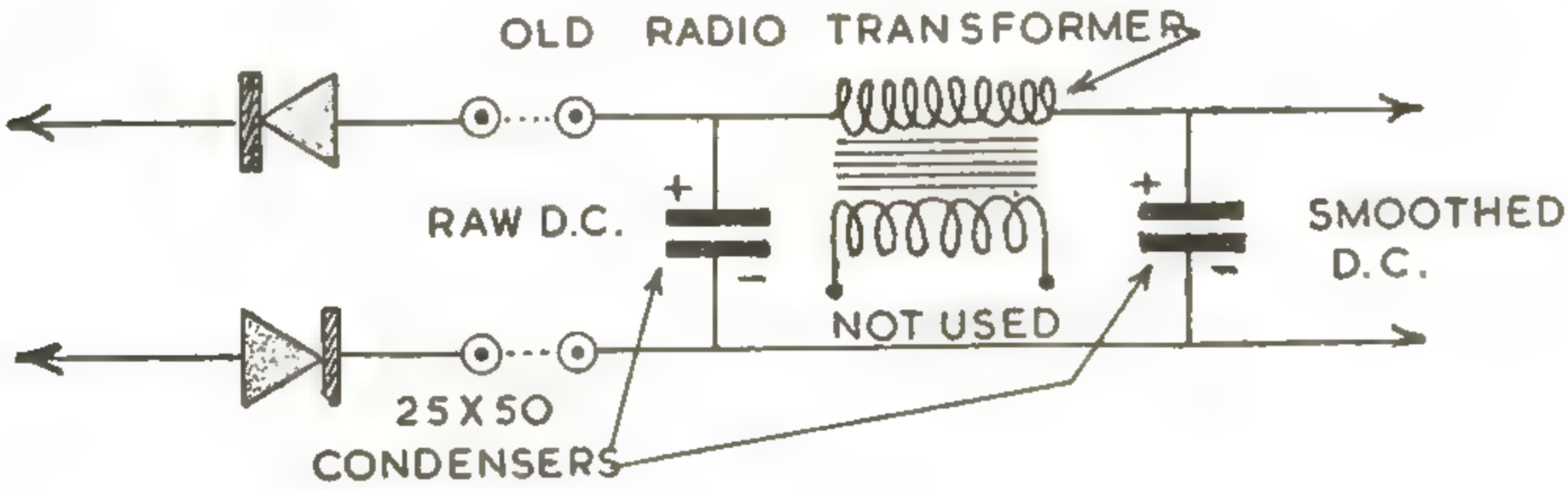


Fig. 27

terminals of a traction power-unit for this purpose. Primarily, it must be remembered that the voltage of the d.c. drawn from a rectifier will generally be from 15 to 25 per cent. less than the a.c. impressed on the rectifier cell; so, should the auxiliary terminals be marked "15 volts a.c." or "12 volts station lighting," the rectified output will be obtainable at about 10/12 V and 8/10 V respectively, depending upon the characteristics of the rectifier cells being used, the amount of smoothing used, and the amperage drawn from the rectified output.

Generally speaking, the more perfect the smoothing of a circuit by the capacity of condensers and the inductance of chokes, the lower will be the percentage of d.c. output available from a given a.c. input. Hence, unless the a.c. input voltage is about double the required d.c. output voltage, super-efficient smoothing circuits should not be considered.

Another point of importance is that if an attempt is

made to draw a d.c. amperage (at any given voltage) above that which the rectifier is rated to pass, the rectifier will get over-heated; and if it is of the copper-oxide type, it will be ruined very speedily. Not only so, it will be found that the available voltage will also drop in ratio to the excess amperage drawn.

In simple terms, it is impossible to draw an added "quantity" (amps.) of electricity from any transformer-

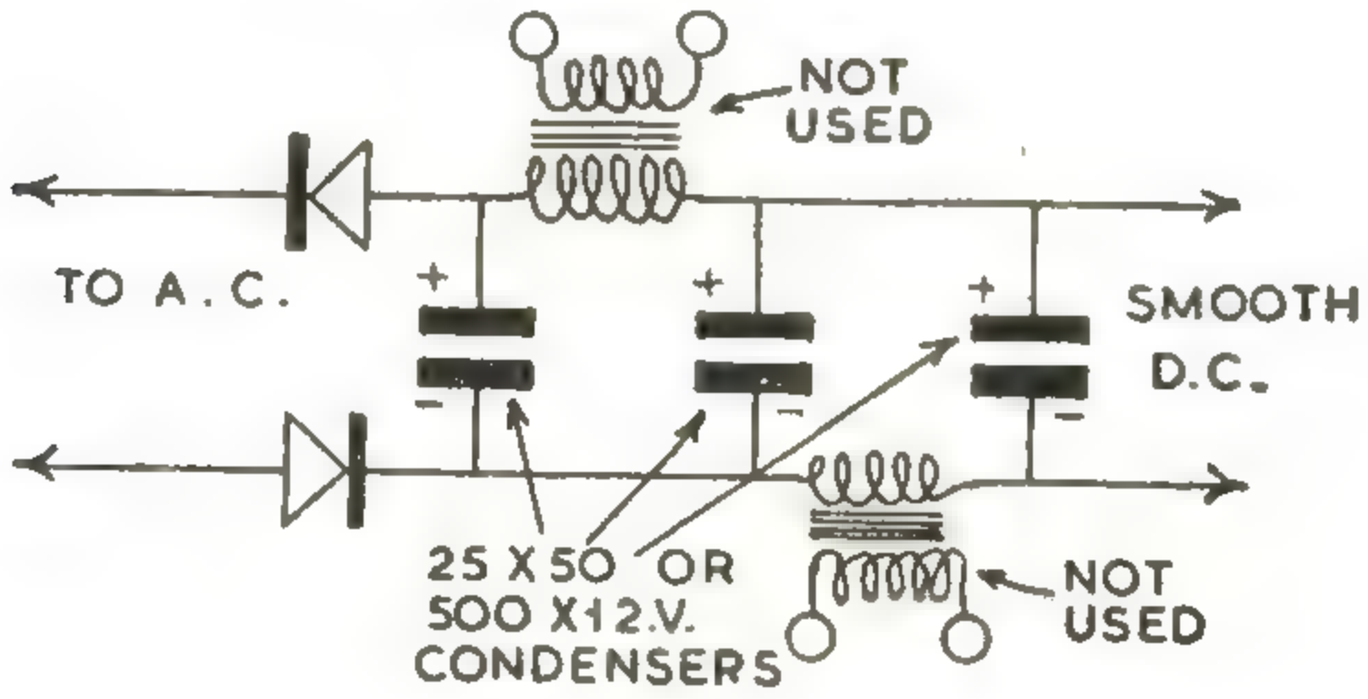


Fig. 28

driven apparatus without losing the "quality" (volts) of the current drawn. This is because an electric transformer (in the mains eliminator) is a self-regulating device, in which the maximum output in watts (see Chapter One and footnote) remains constant within its working limits; also, if the amperage increases, the voltage decreases, and *vice versa*. Bearing this fact well in mind, care must be taken never to attempt to use the auxiliary terminals providing low voltage a.c. supply from the mains transformer of a power-supply unit for signal motor power without bearing in mind that the long-suffering transformer has also to provide current for running the locomotives from its other secondary windings, *B* and *C*, in Fig. 29. Unless this is studied, it will be found that locomotives will jerk in running every time a signal or point motor comes into operation, an effect which is particularly noticeable when some of the commercial low-

resistance double coil point-motors are being used. These motors give tremendous power, and will readily work the four sets of point-blades of a scissors crossover, but their drain in amps on the supply is very high.*

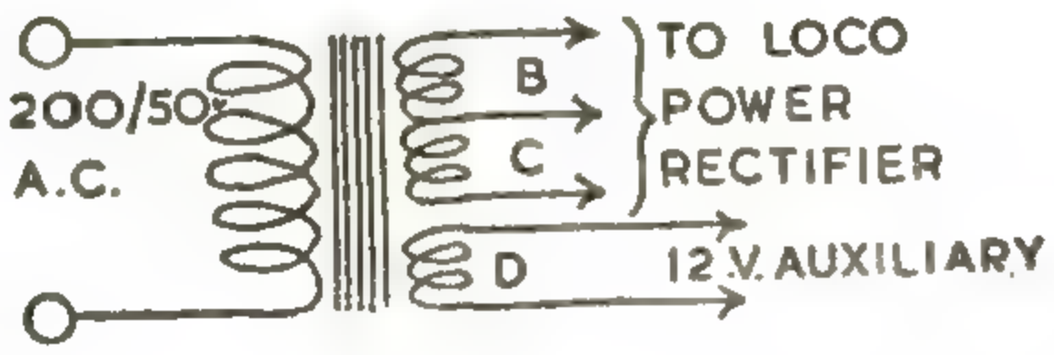


Fig. 29

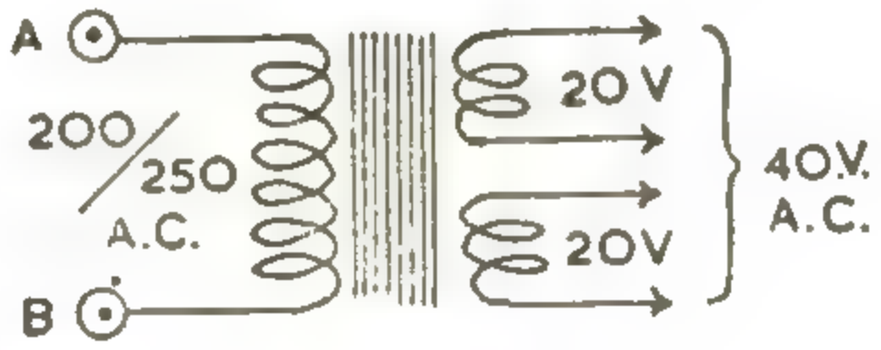


Fig. 30

If any doubt exists as to the capability of deriving the required d.c. voltage and amperage from the auxiliary terminals, it is far better to make up an entirely independent power-supply rectifier unit for the signal and point-motor current from which adequate wattage can be drawn. A mains transformer wound with a 200/240 V primary and a centre-tapped 40 V (or 20 × 20 V) winding for its secondary, wound with fairly heavy-gauge wire, will provide more than enough a.c. current, which can then be rectified as already explained, and obtained at 12 to 15 V d.c. (see Fig. 30).

Very often, a radio mains transformer with a burnt-out h.t. secondary winding can be purchased very cheaply from a wireless repairers, and the two low-voltage secondaries can be joined in series to give either 4 × 2 V or 6.3 times 2 V; i.e., 8 V and 12.6 V respectively. The connections required to produce this voltage are shown in Fig. 31, and such a rewired transformer will give this pressure at three or four amperes without undue overheating.

* The power on most solenoid motors will be approximately the same whether a 6- or 8-V type is used on 8 V d.c. or 20 V raw a.c., whereas a 10 or 12 V solenoid motor will only develop about 75 per cent. of its normal power when used on 20 V raw a.c.

In connecting the two secondaries in series, care must be taken to ensure that the two windings " boost " each other (i.e., add their voltages) and do not " buck " (i.e., neutralise each other). To ensure that this is so, the coils should first be joined as in Fig. 32A (i.e., both windings in the same direction) when a lamp of the maximum voltage of both coils should light. If, however, it does not, then the coils should be connected as in Fig. 32B. If dry-cells

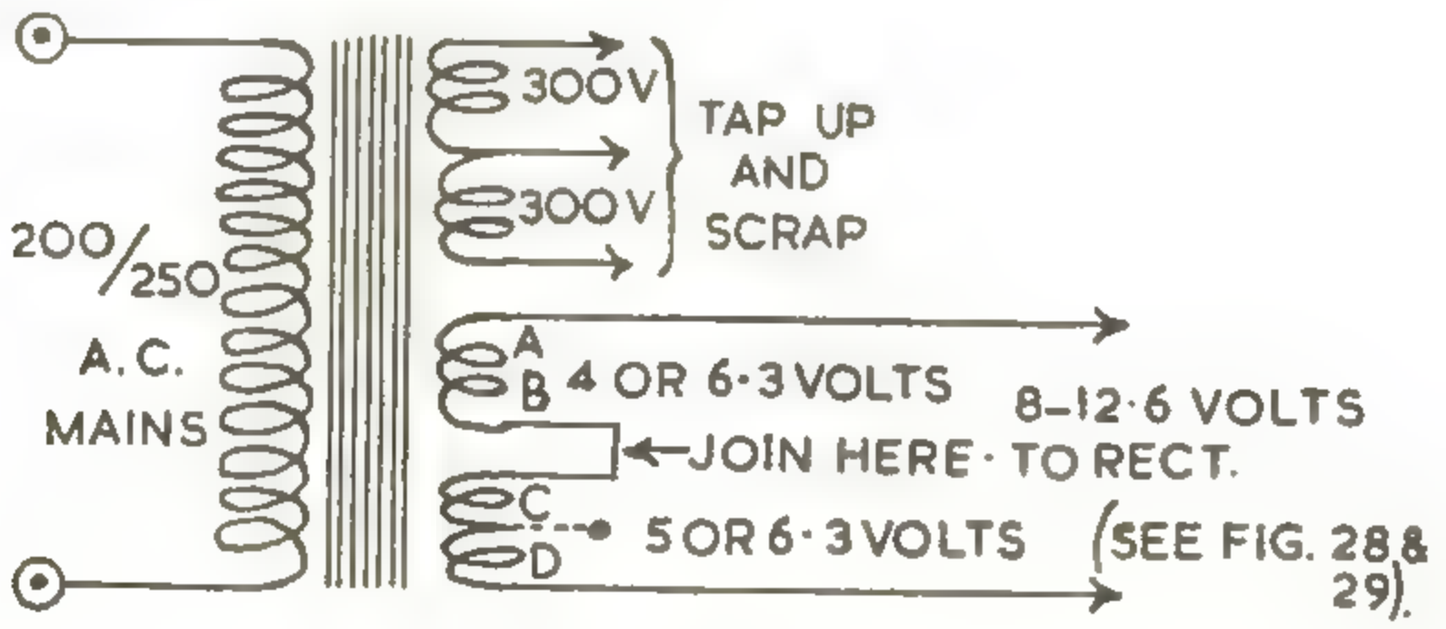


Fig. 31

are to be used to provide the current for an electric signals ling system, they should be of ample proportions, such a- those used for electric house bells. Smaller cells are satisfactory if the railway is only used at odd times and a " main " on/off switch is fitted as already mentioned.

It may be remarked that a working voltage of 12 or 15 V can just as easily be built up by connecting single dry-cells in series as by any other method, moreover, they are easily and cheaply replaced when exhausted. Primary batteries of the Leclanchè type are also very reliable, and are capable of giving exceptionally long service on light load, provided that they have time to recoupe themselves between discharges. Because they are liquid-electrolyte cells, they should be placed at floor level under the layout, and should be topped up with distilled water when the level of the electrolyte falls below the level of the pitched top of the porous-pot. Leclanchè cells will last for years if treated well, and are ideal for signal power

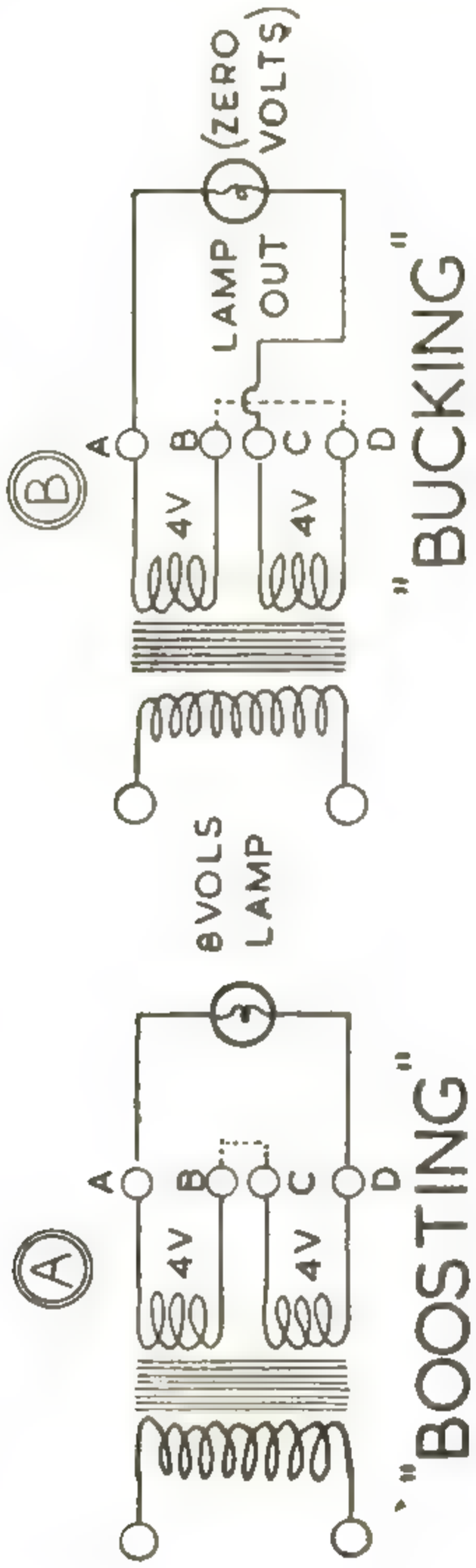


Fig. 32

in every respect if a layout is not being run from the house-main supply.

In the writer's opinion, the ideal voltage for all track-circuiting and signal operation is 12 V d.c., and, provided that the rail-head is reasonably clean—not necessarily bright, but free from grease and grime — this voltage will give trouble-free working; this has been proved to be the case on a layout of over 1,000 ft. run (in "O" gauge), where running was taking place eight hours a day, seven days a week, continuously!

Higher voltages have been recommended (even as high as 50 V) with a view to "breaking through" the layer of dirt on the rails, but it may be as well to state frankly that, under certain adverse conditions, even a 50-V (a.c.) shock can be very uncomfortable, particularly if the layout is situated in a room with a damp concrete floor. Moreover, if the said 50 V should at any time be additive to the traction voltage of 12 V, one has to deal with a possible 62 V, and this potential is relative to the "earth" of the layout as well as, perhaps, to the real earth of the room floor, gas-pipes, and the like.

The mention of the "earth" of a layout brings up another very important point to be considered when wiring a model railway for electrical point and signal operation. It is the paramount advisability of nominating one or two lengths of 7/22 bare copper wire laid beneath

the layout under the full extent of all the tracks to do duty as a pseudo-earth, to which all return wires from all track apparatus can be taken. Feed wires can also be run from this "earth" network to all running-rails which are *not* cut for signal track-circuits, as well as from one side of all station and signal lamps; in fact, it will be found that by the use of this "earth" grid, most apparatus can be made to operate with but one feed-wire, return to supply-source being made *via* the earth grid.

On layouts of a roughly circular or oval shape, it will be found a great help if the "earthed" running rails are always made those on the *inner* rails of each track because, by this simple provision, one can immediately determine which rail is track-circuited—*viz.*, the *outside* rail of each oval of track. This will be found to simplify signal circuiting on a large layout to a considerable extent. All track-circuiting, whether on two or three-rail layouts, should always be neatly carried out and all wires to circuited running-rails must be soldered.

CHAPTER FOUR

THOSE interested in semi-automatic model railways seem usually quite content to make do with the most ramshackle rolling-stock, and scenic effects are usually conspicuous by their absence. All efforts appear to be concentrated on the installation of every conceivable control " gadget " whereby the locomotives can be made to do almost anything desired. There is, however, no gainsaying the fact that the devising of the electrical and mechanical apparatus necessary, is intensely interesting —particularly to the electrically-minded among the fraternity. Such work, none the less, takes a deal of time which cannot always be spared from that demanded by other branches of the model railway hobby.

The secret of lasting interest and success in model railways is wrapped in one word—compromise, which should enter into every ramification of the hobby; for pedantry in model railways neither interests the majority nor pays good dividends. So it is with the fully-automatic railway, and its bearing upon power point and signal interlocking with traction power-supply; the human element is lacking to give the sustained operational interest. There must be fallibility—the possibility of an accident.

In Fig. 33 is given an experimental selective circuit whereby a pair of facing points may be made to operate according to the wheelbase of the locomotive approaching them. It will be observed that the auxiliary lengths of third rail (*A* and *B*) are so spaced from each other that the

collector shoes of a short tank locomotive will interconnect them (through the metal of the locomotive collector itself) and bring into circuit battery *C*, which will cause the points to move to branch through the medium of a normal point solenoid. (Type Fig. 3). The locomotive afterwards resets its own points when reaching the auxiliary studs

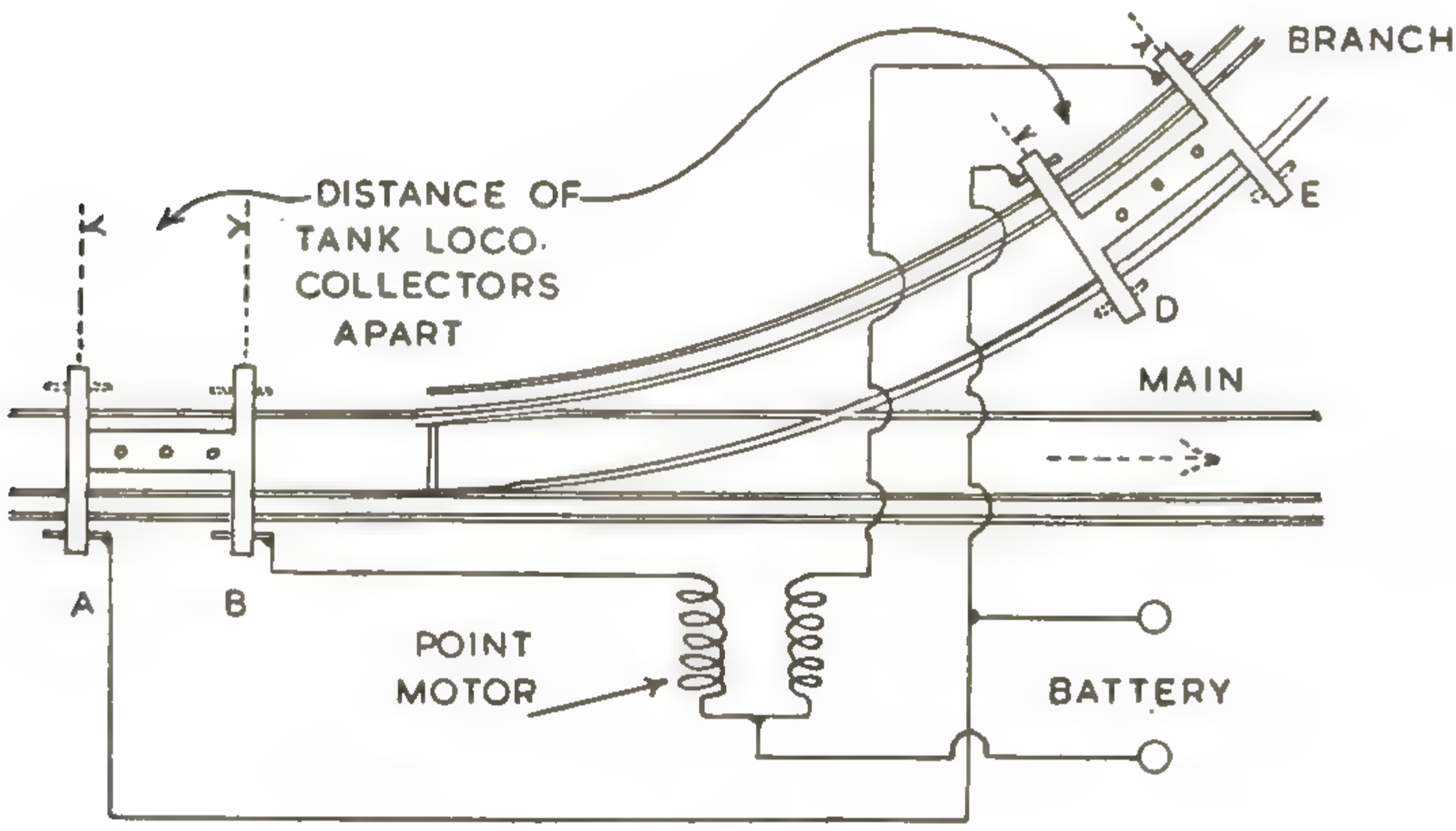


Fig. 33

D and *E*, which should naturally be placed at more than an average train's-length from the points. On the approach of larger tender engines, with more widely spaced collectors (maybe one on the tender), no connection is made between *A* and *B*, and the main-line train thus automatically selects the main line route, since the points are not moved.

If desired, the auxiliary lengths of third rail may be placed on the opposite side of the running-rails to the continuous third rail, as shown dotted in Fig. 33, or one short length may be laid one side, and the other length opposite; either way is equally effective, for all that is required is that a circuit is made from one collector bar

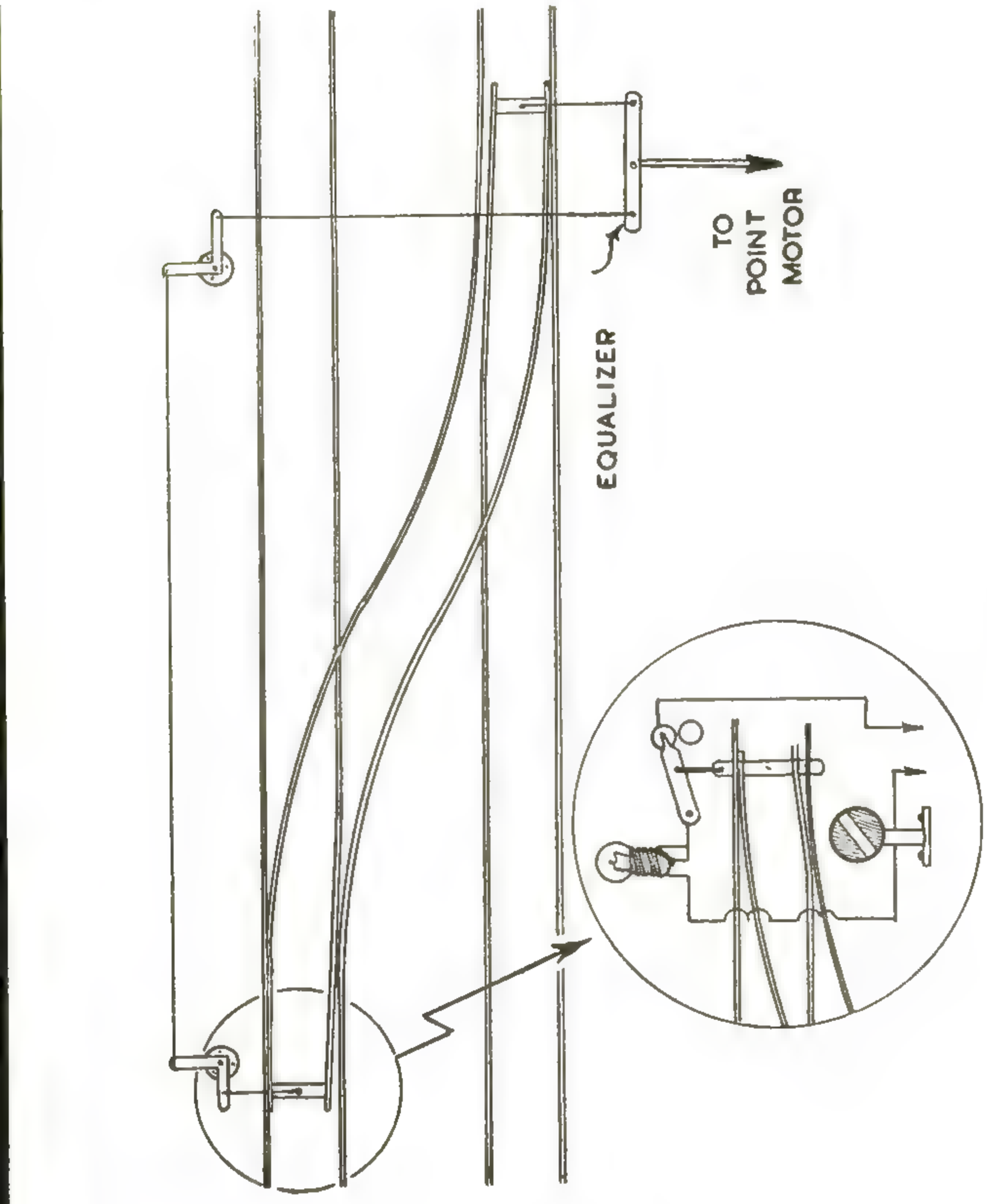


Fig. 34

to the other—the locomotive power feed being interfered with in no way.

In the case of trailing or facing crossovers, where two sets of point-blades are to be worked simultaneously, it will be found best to operate both together, mounting the motor equidistant from both points, and coupling with rodding and bell-cranks in the orthodox manner. The operation of four blades in this way naturally demands

the use of a more powerful motor, and the blades must be pivotally mounted—not sprung extensions of the point-rails; this proviso applies equally to both 4 and 7 mm. scales.

If it is desired to signal a trailing crossover by a ground-disc, the latter may be directly coupled to the point-operating rodding or, alternatively, switched into circuit with a separate lever in the box frame by means of a

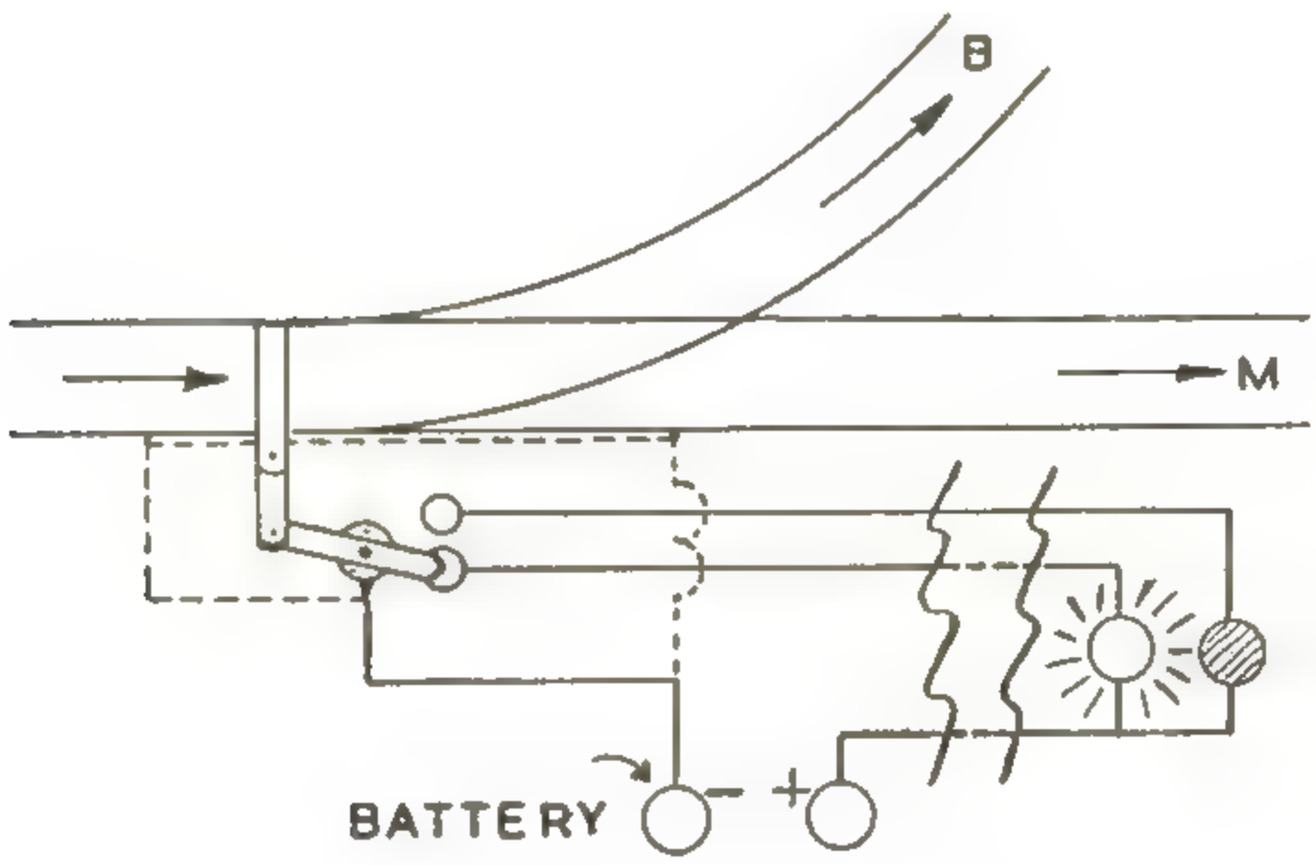


Fig. 35

simple wafer switch connected to the tail end of the point stretcher bar, as shown in the inset to Fig. 34. In this arrangement, it will be impossible to give the correct signal indication for crossing over until the points are correctly set; also, by running a series lamp (*L*) in the signal box, it is possible to indicate the position of the points visually, before running over them.

Many other variants of this simple, yet intriguing principle readily come to mind. For example, in Fig. 35 is shown the method by which a simple facing point can be made to indicate its position—positively—at the control desk by means of a two-position wafer switch on the stretcher-rod. According to the position of the switch blade, either "Main" or "Branch" will be indicated at the main control point.

Another useful application of the stretcher-bar switch

AND POINT OPERATION

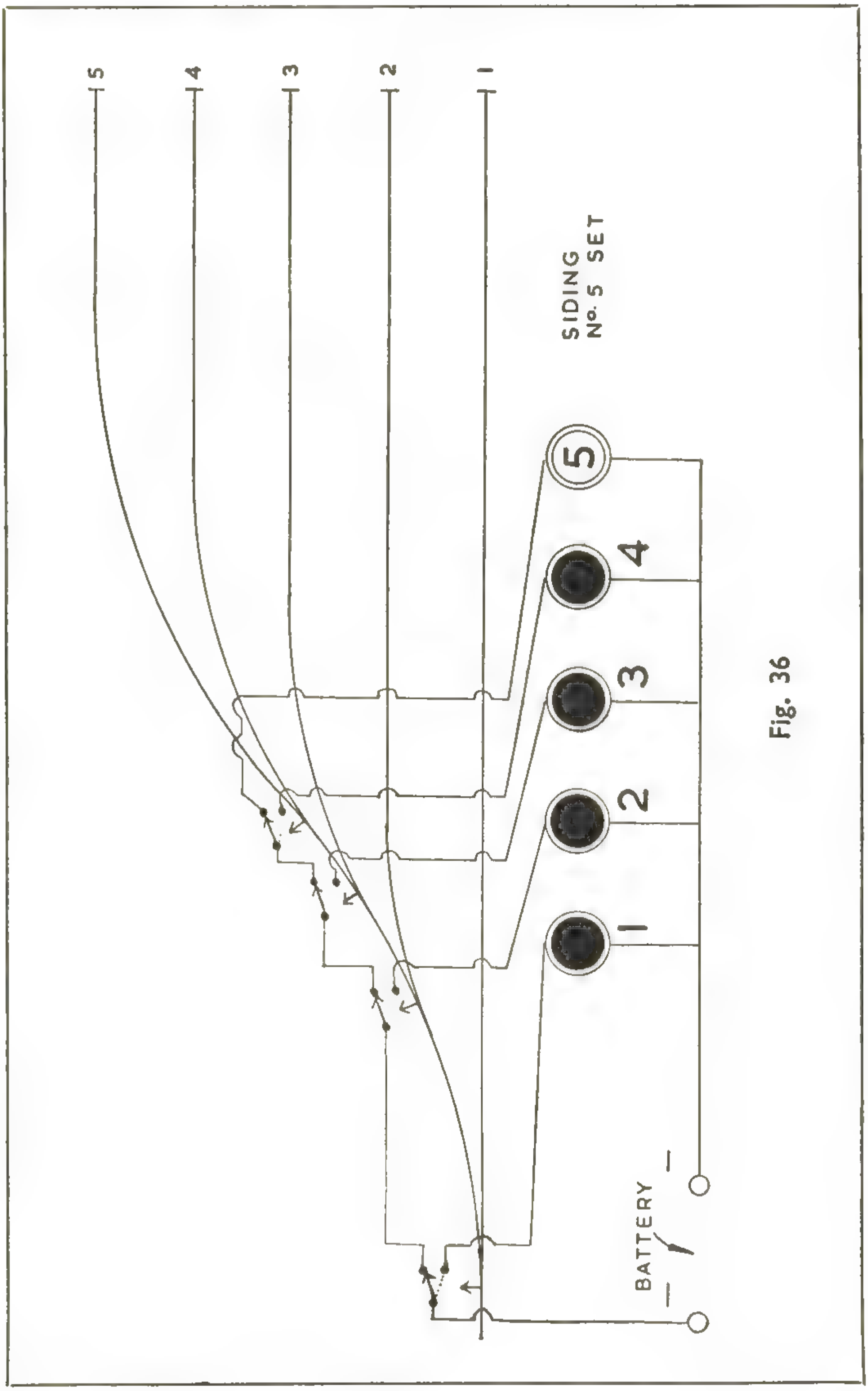


Fig. 36

is depicted in Fig. 36, where it will be seen that five roads in a ladder siding have their entry point positions indicated back to the box by wiring four separate stretcher switches in series. By this means, the correct road may be set to any siding by merely moving the four point-levers until the correct indicator lamp lights on the desk, even if that part of the layout is out of sight.

Perhaps the greatest advantage of this type of indicator is that—if the switches are neatly and accurately made—the indicator lamps will fail to light unless the point-blades are well and truly "home." This surety is not attained by merely observing the position of the point-operating levers—particularly in the case of a.c.-operated signal motors, which have a nasty habit of "bouncing" after the power-stroke. There is also the spectacular aspect to be borne in mind when fitting indicator lamps at the control desk to do duty as visual "locking-bars," and any time spent in their installation will be more than paid for when exhibiting the layout's possibilities.

It will be understood that the schemes outlined in Figs. 19 to 33 apply only to three-rail electrification and stud contact systems, not being possible with "two-rail"; but this disability does not apply to Figs. 34, 35 and 36, which are applicable to all forms of electrification. It may also be said that the schematic circuit of Fig. 36 may be readily adapted to indicate arrival roads on a common home signal at larger junction stations, the indicator lamps being mounted on the "home" post below the semaphore arm. In this case, also, arrival platform indication may be additionally indicated in the control desk by lamps wired in series with those on the home signal post; but care must be taken to ensure that the total voltage of the two lamps used for each road is the same as that of the supply, otherwise both lamps will only glow dimly. (Fig. 37).

There always has been a great diversity of opinion over the manner of point and signal operation and its relation-

dictated by the circumstances of each individual layout, some systems being favourable for use with "O" gauge steel, brass or tinplate track, and others for "OO" "three-rail."

In the automatic point-motor circuit which will be considered first (Fig. 38) it will be observed that there is the added advantage that the points are operated by the same

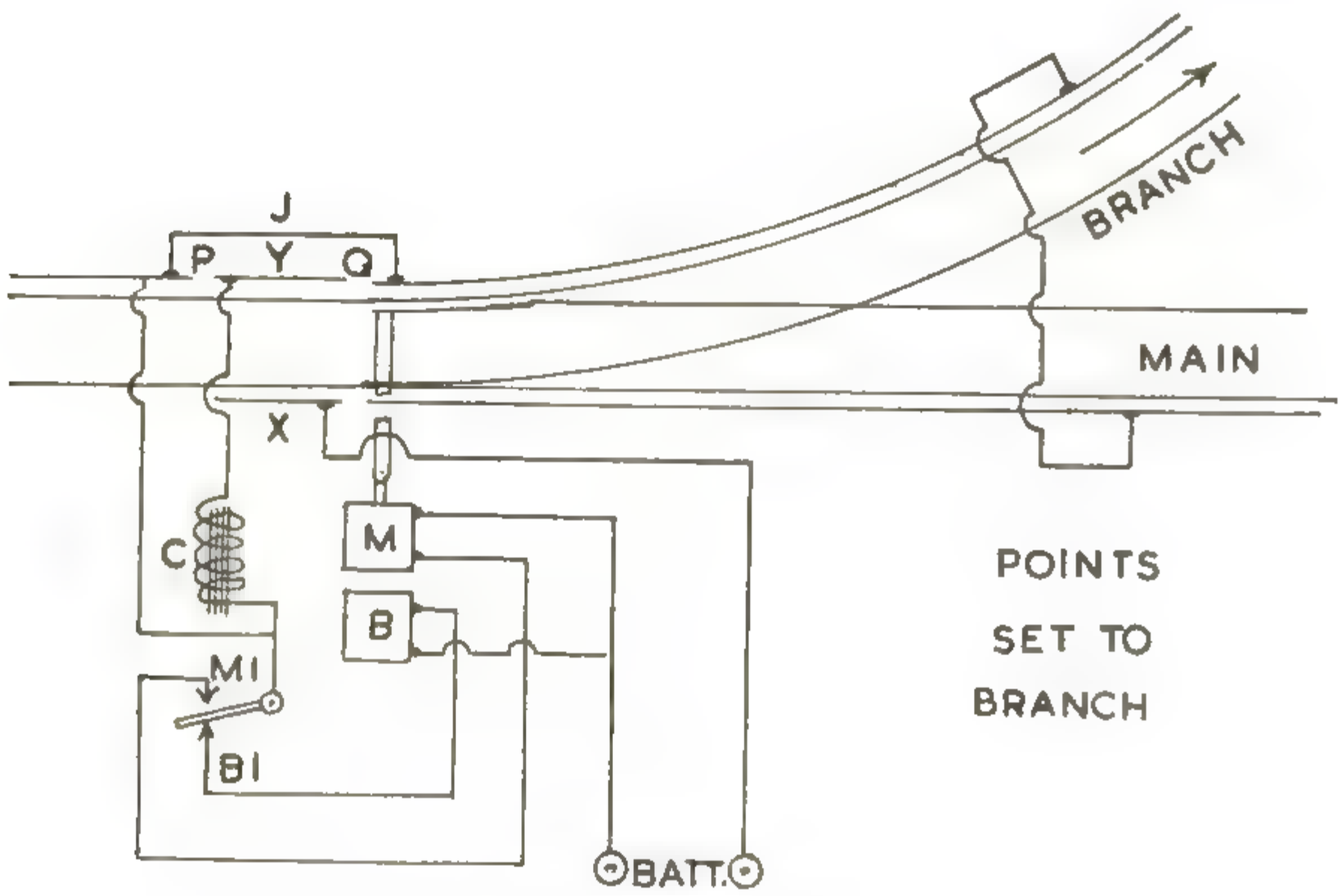
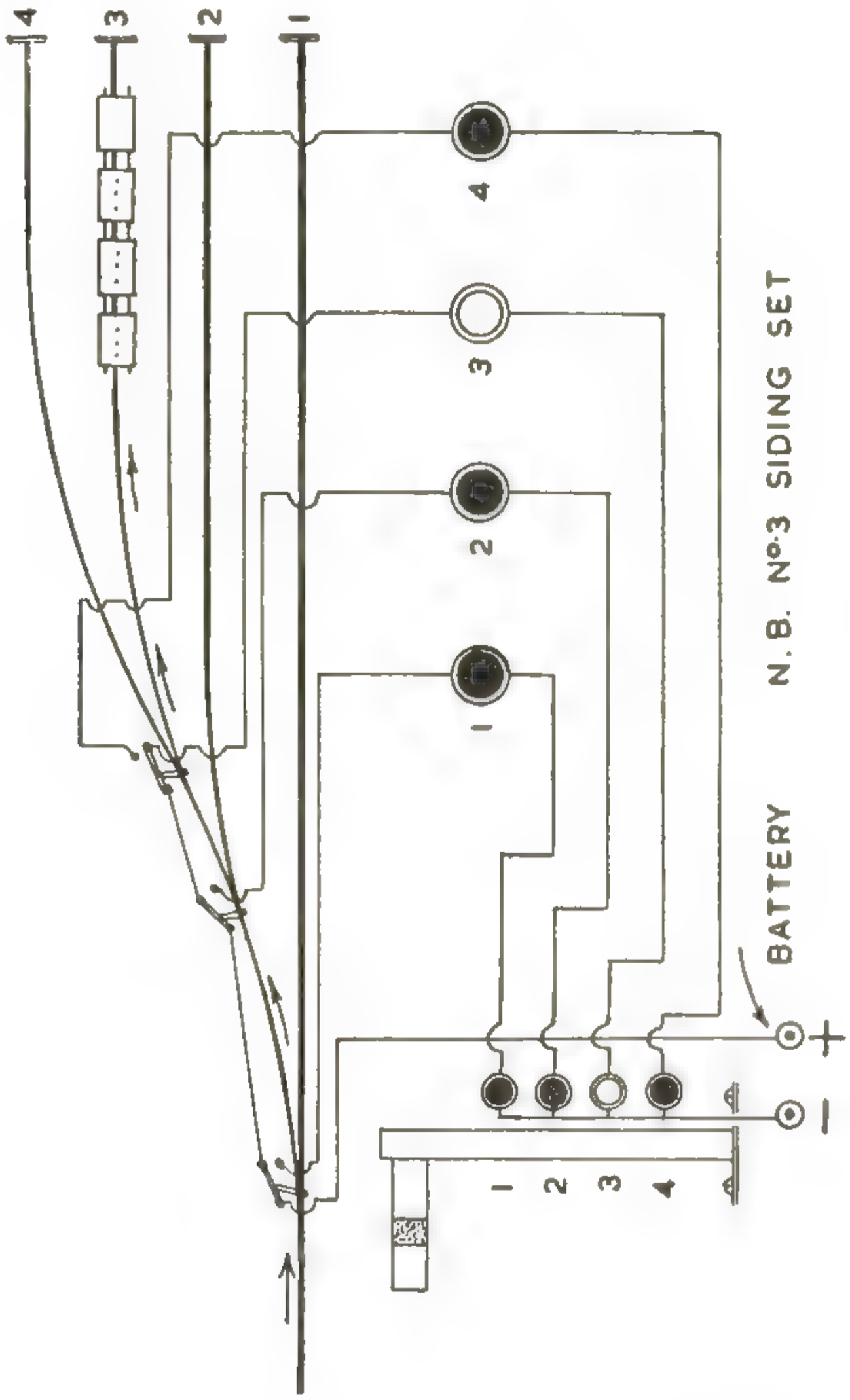


Fig. 38

resistance or switch that controls the running of the locomotives, the latter working its own points according to the wish of the operator at the controls. For normal "outside-third" electric track, the live rail is cut at *P* and *Q* and a 1-in. long section (*Y*) isolated; the two ends, of the third rail are connected by a jumper (*J*). Immediately opposite *Y*, is fitted another 1-in. long piece of "third" rail (*X*), which is so arranged that the collector of the locomotive touches both *X* and *Y* as it passes towards the facing points. The principle of operation of this simply-fitted "gadget" is as follows: When the collector shoe of the engine contacts *X* and *Y* simultaneously, a circuit



N.B. N°3 SIDING SET

Fig. 37

ship to train movements. Some authorities claim that an approaching train should automatically lower its own signal and operate its own points, whilst others demand that every point and signal should be worked by the person running the layout. There are also those who feel that power to the locomotives should be cut off automatically when a signal is " on," being restored when it goes " off." The writer does not propose to suggest either of these basic principles, or to attempt to guide the reader in his choice; for the selection is one which is very largely

from the local battery is completed *via* either coil of the point motor (*M* or *B*), selection taking place according to whether the locomotive power is on or off (or fast or slow) at the instant of its passing over *X* and *Y*. If the traction current is at full voltage (and it would normally be, when approaching the straight-run main-line) it passes from the third rail to the locomotive motor *via* coil *C*, which attracts to its iron core an armature which is normally held in contact with contact *B*1. Upon movement, contact is made with *M*1, which switches the local battery current through point solenoid coil *M*, thus moving the points to main from their normal " branch " setting. If, however, the locomotive traction voltage is low or " off " whilst passing over contactors *X* and *Y*, then the coil *C*, not being sufficiently energised (or not energised at all) does not lift the armature from *B*1 to *M*1, and the local current—switched in by way of the locomotive collector-bar touching both *X* and *Y* at once—passes from the battery through point-motor coil *B*, thus resetting the points for the branch line.

The equipment needed to produce this point-setter is very simple, no modification at all of the locomotive collectors being necessary. The simple relay shown may be made by suitably modifying an old electric bell movement in a similar way to that described in the last chapter, two auxiliary contact-studs (*M*1 and *B*1) being needed instead of the one shown in Fig. 20. Most of the other materials can be obtained from the scrap-box.

The winding of the relay coil must be made with 10 or 12 ft. of No. 26 s.w.g., d.c.c. copper wire, there being no necessity to wind it evenly, for it is an accepted fact that, in wires of No. 26 s.w.g. or smaller, the gain in space does not, as a rule, warrant the care and attention needed in layer winding, and such sizes may be wound more or less haphazard. This also applies to all solenoid windings in fine-gauge wire.

It may also be noted that for short-term service—such

as point operation—where a coil is energised only for short periods with long intervals between the application of current, the thermal capacity of a coil will permit of a greater dissipation of energy in its winding without overheating it dangerously than will a coil that is constantly energised. Haphazard, or " scramble " winding dissipates

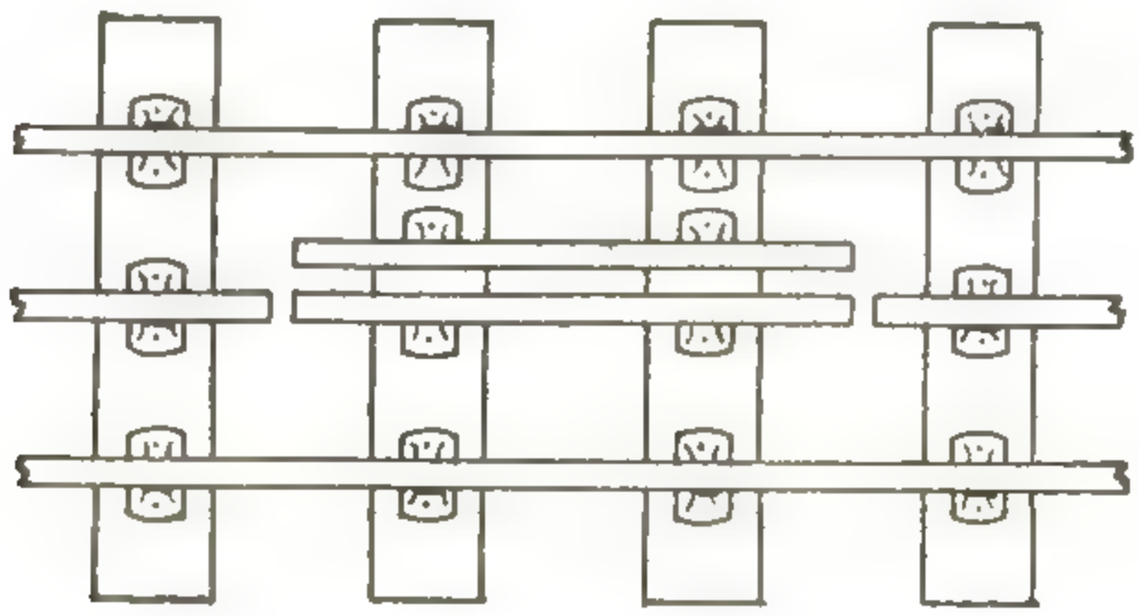


Fig. 39

heat more readily than does an even layer-wound coil by reason of the interstices between the crossed turns.

In the point-setter shown in Fig. 38, if a " centre-third " rail is being used on the layout, then a slight variation in the positioning of the pieces *X* and *Y* must be made; as shown in Fig. 39. Two pieces 1 in. long must be fixed between the running-rails as closely as possible side by side, though not in actual metallic contact with each other or the running-rails. Short pieces of conductor rail may be used, bent down to a ramp at each end and soldered to half chairs which are spiked down to sleepers with a piece of thin card between the two lengths of conductor to prevent them touching each other.

A variation of Fig. 38 is that shown in Fig. 40, which

does not involve the use of a local source of point-operating power. In this type, the locomotive, in passing over contactor *A* sets the points for main (if locomotive power is on whilst passing the contactor); then, when passing over contactor *B*, it resets them to branch. Traction power is always left "on" when passing *B*. Both contactors should be set just over maximum train's-length from the tips of the point blades. (*T.L.*).

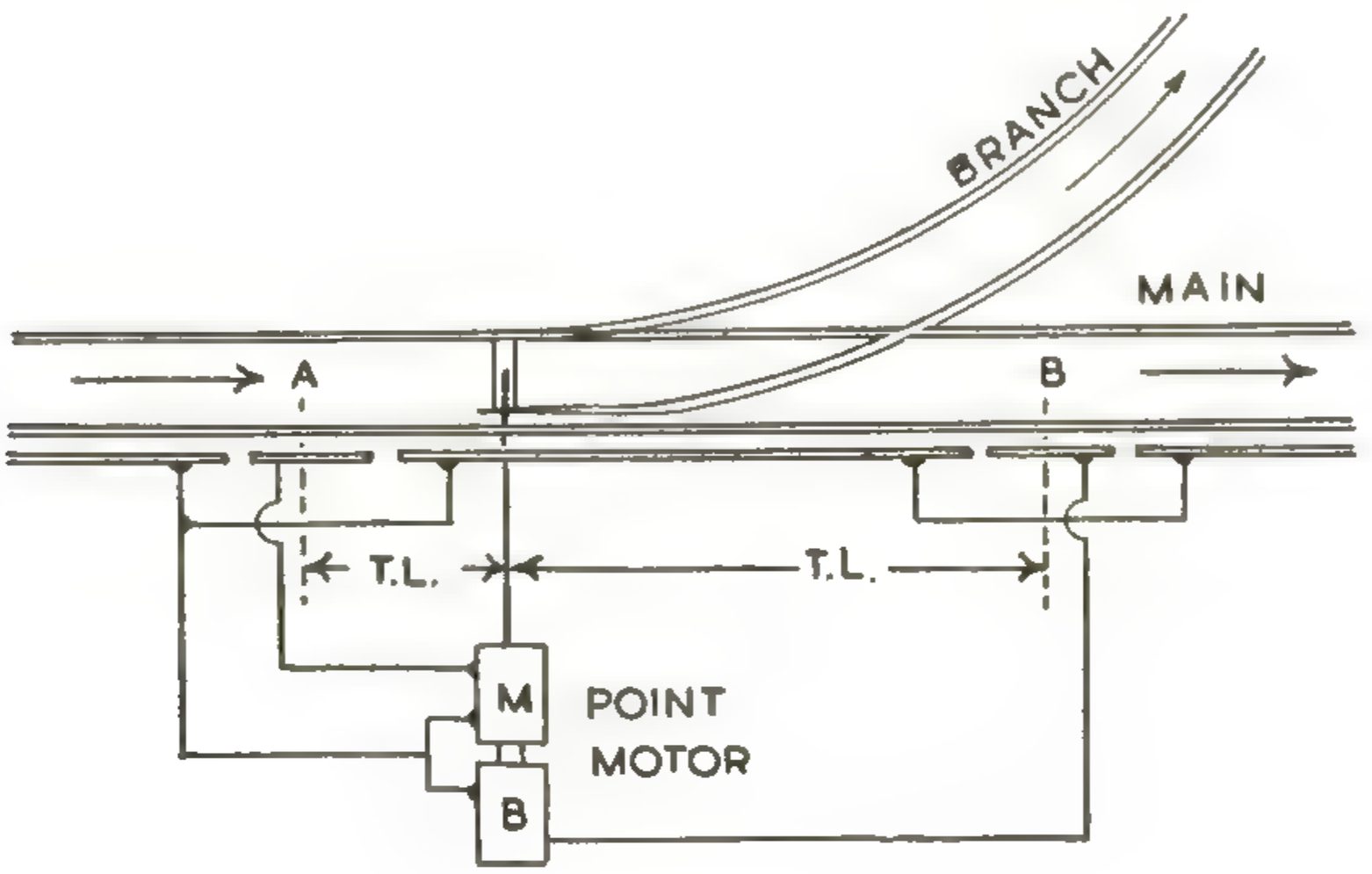


Fig. 40

The only disadvantage to this system is that such points cannot be used in a trailing direction, but a little experiment will soon suit the contactor positions to the type of traffic using the junction.

The average amateur regards the automatic operation of colour-light signals with rather mixed feelings, probably on account of the rather elaborate circuiting arrangements associated with this form of model signalling. By studying Fig. 41, however, it will be seen that the supposed complications do not exist in practice, and although the circuit shown does not operate in strict accord with prototype working, it will enable a train to work its own signals satisfactorily. It may be mentioned that the underground system of the L.P.T.E. is signalled upon a similar system

in which all signals show a green indication so long as there is no train, but immediately one passes a green signal, the latter turns red until the train has passed the next section, thus ensuring one empty section between trains.

In Fig. 42 (in which the power " third rail " is not shown, for reasons of clarity) a vehicle is supposed to have entered

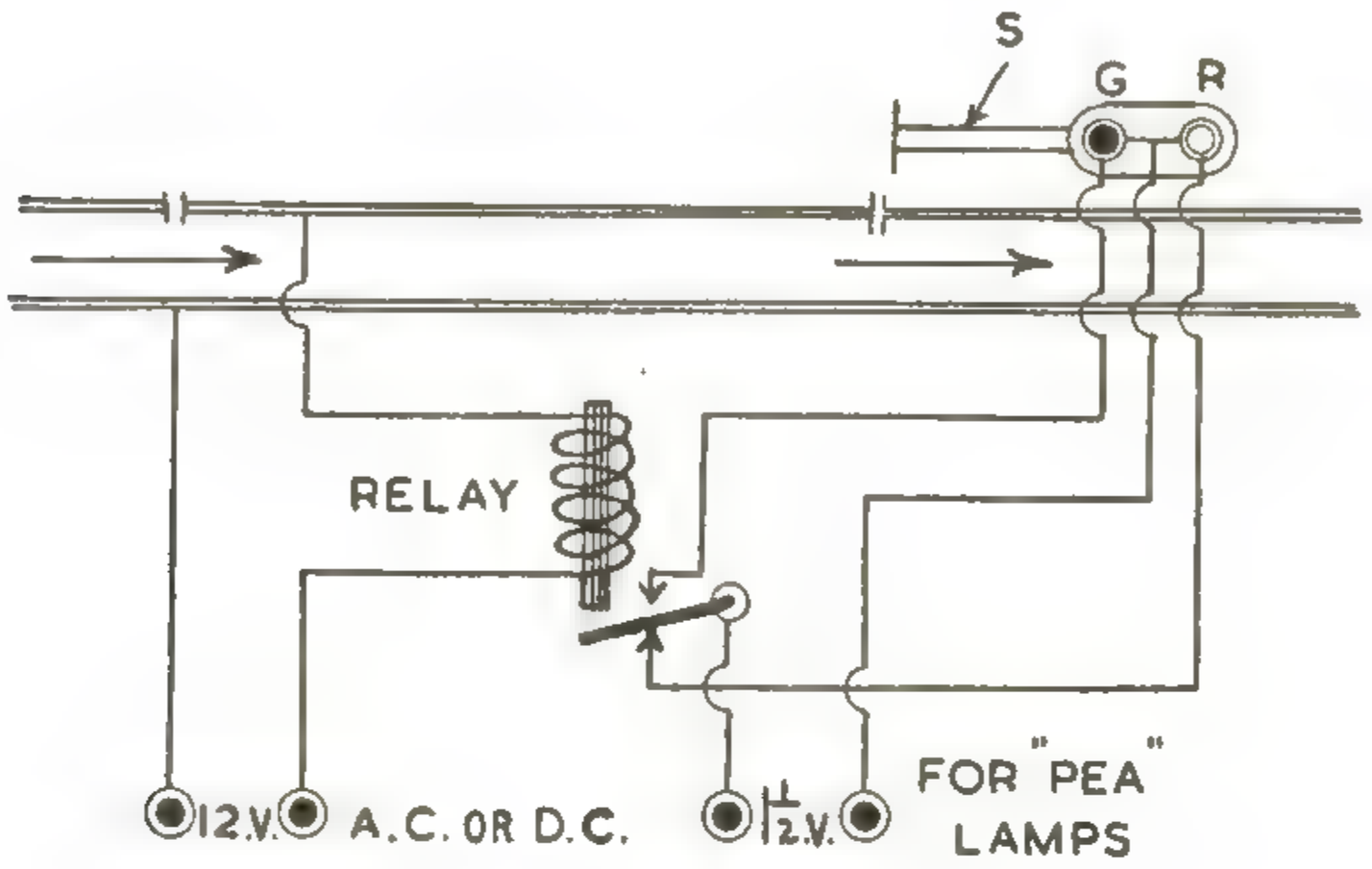


Fig. 41

section two from section one. When a section is unoccupied a green light is shown, but when a train enters the section (e.g., section 2) a circuit is completed through the red lamp, and at the same moment the green lamp is extinguished by the electro-magnet in the simple relay breaking the feed thereto, the red light remaining on whilst the train is in the section. When the train leaves the section, the red light circuit is broken and the relay vane also returns to its original position, thereby relighting the green lamp. Care must be exercised in the positioning of the signals, placing them ahead of the section gaps in the rails, so that the train reaches the signal before entering the track section from which that signal is operated.

If it is desired to give visual indication on the main control panel that a given section is clear, it is a very easy matter to take a pair of wires from the green lamp of each

signal to a white lamp in the signal box; then, as each section clears, the desk indicator lamps will light up, whilst when a section is occupied, there will be no light on the desk. These additions are shown dotted in Fig. 42. The relays necessary for the operation of this scheme may be of the very simplest construction, and can be made from converted electric bell movements, as shown in Fig. 20, two contacts being fitted instead of the one there shown. The vane or armature can be arranged to return to the

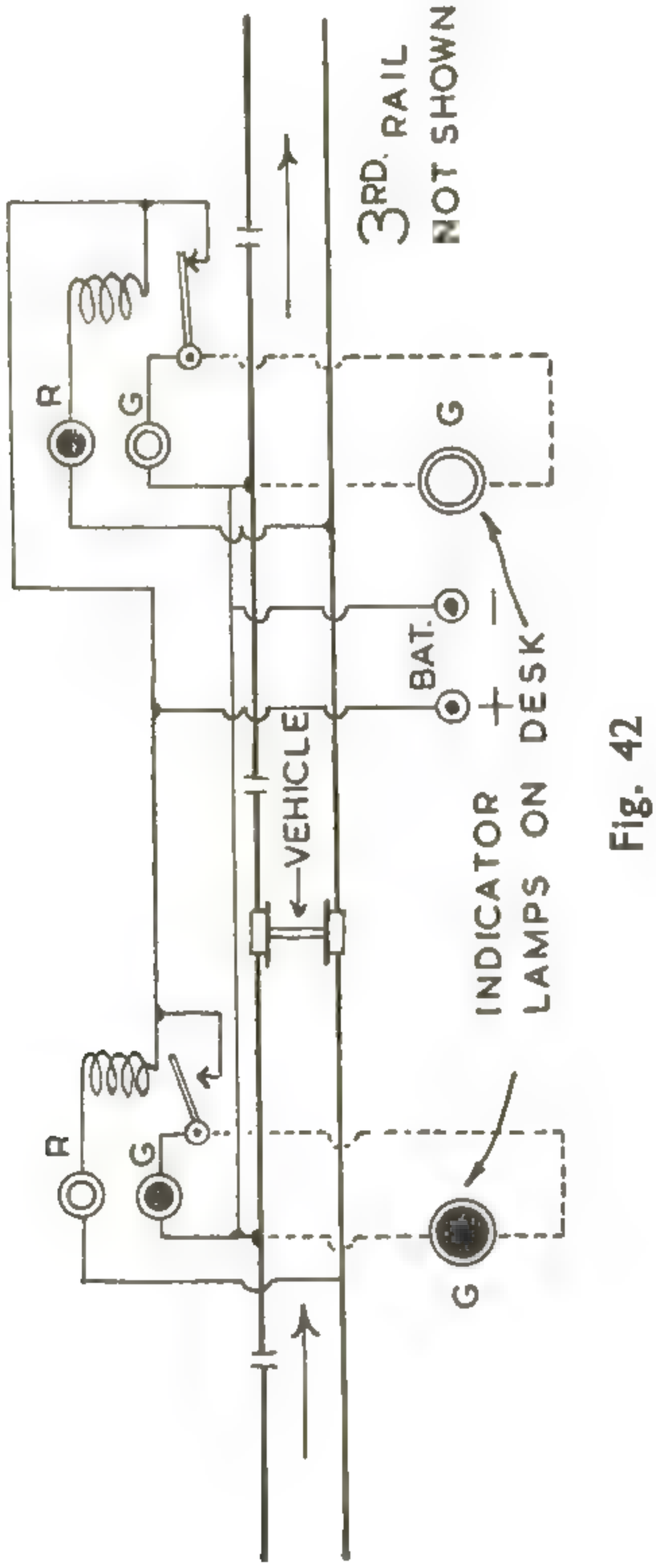


Fig. 42

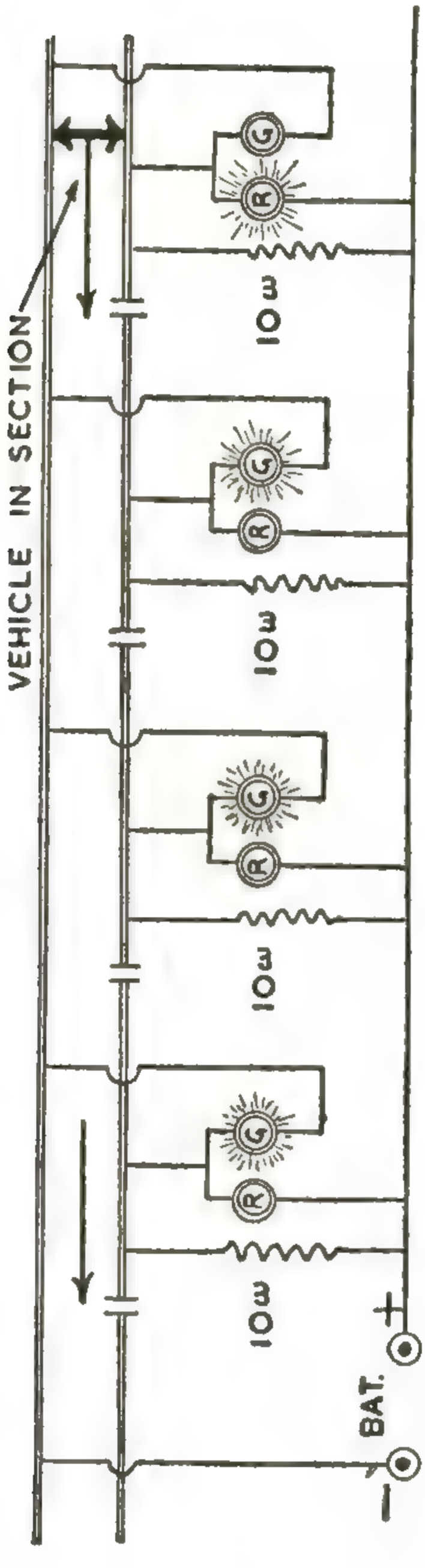


Fig. 43

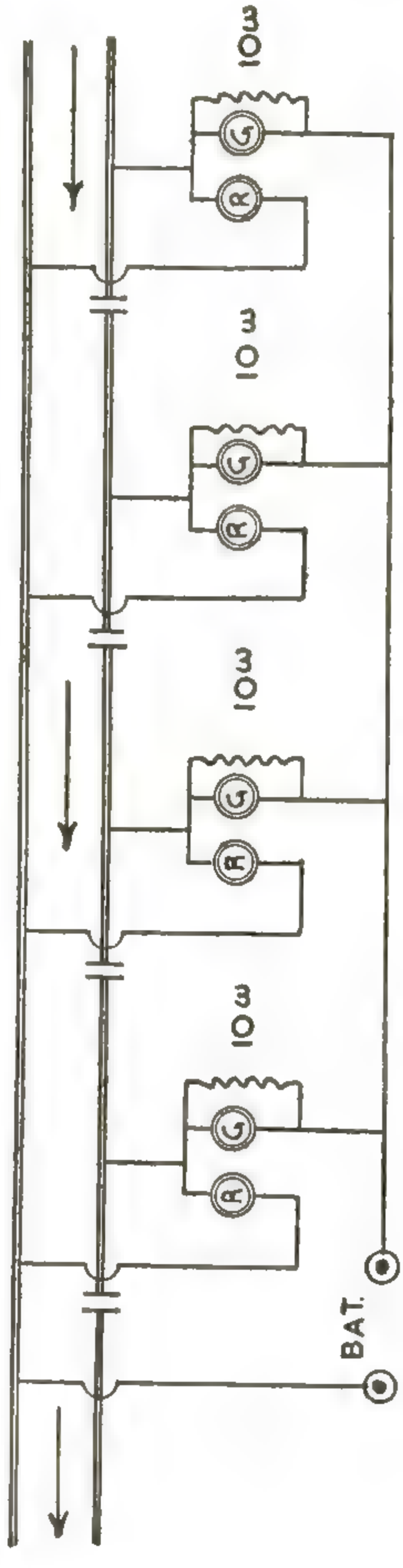


Fig. 44

lower (green) position by gravity if the magnet bobbin is mounted vertically.

Another scheme is depicted in Fig. 43, where it will be seen that the green lamps are kept alight by the current

passing through resistances of 10 ohms, which are placed in parallel across the red lamps. These resistances can be normal one-watt radio resistances, which are purchasable quite cheaply at any wireless repair depot.

In the circuit of Fig. 43, the normal colour of the signals is green (as in circuit Fig. 42), but if it is desired to reverse the system, given a normal red indication, then the circuit of Fig. 44 must be used; then the normal indication will change to green when a train enters a section. It is well to remember that in both the circuits of Figs. 43 and 44,

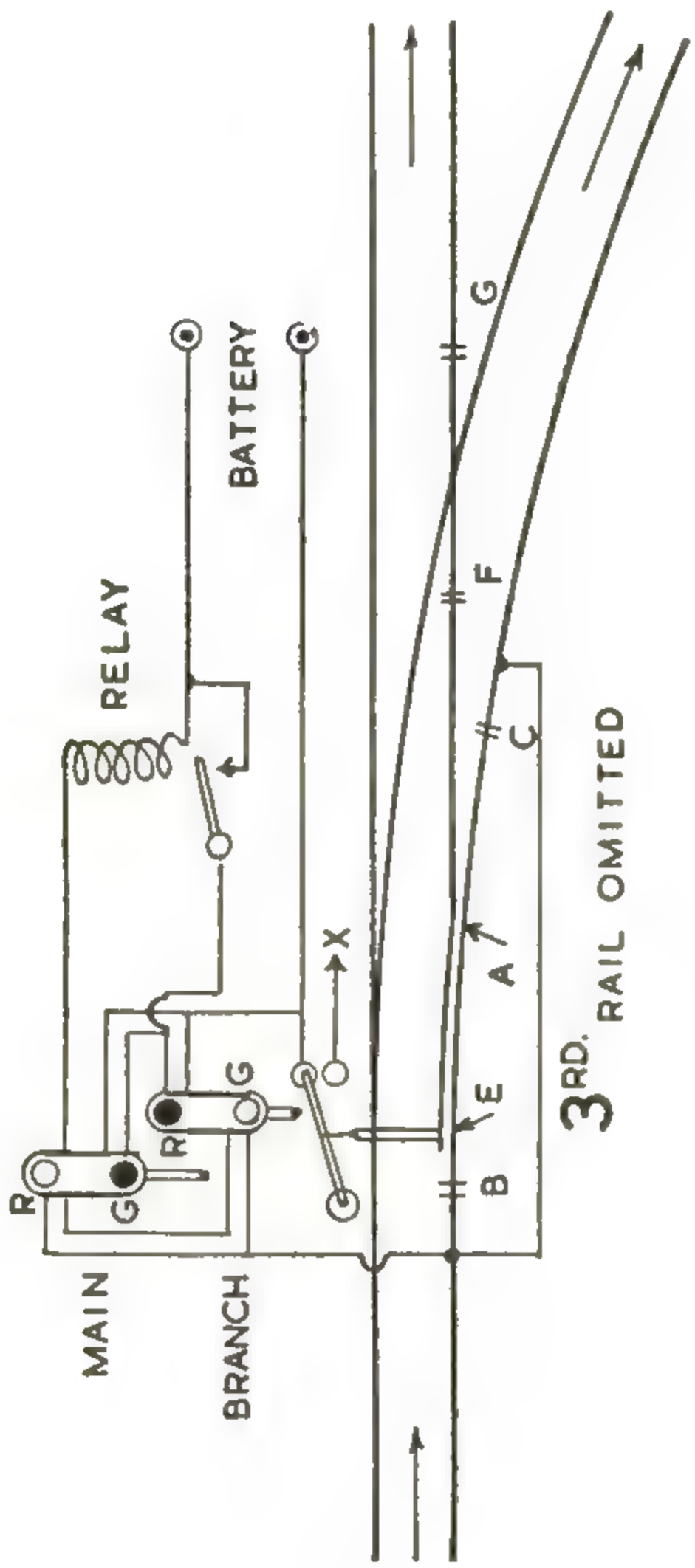


Fig. 45

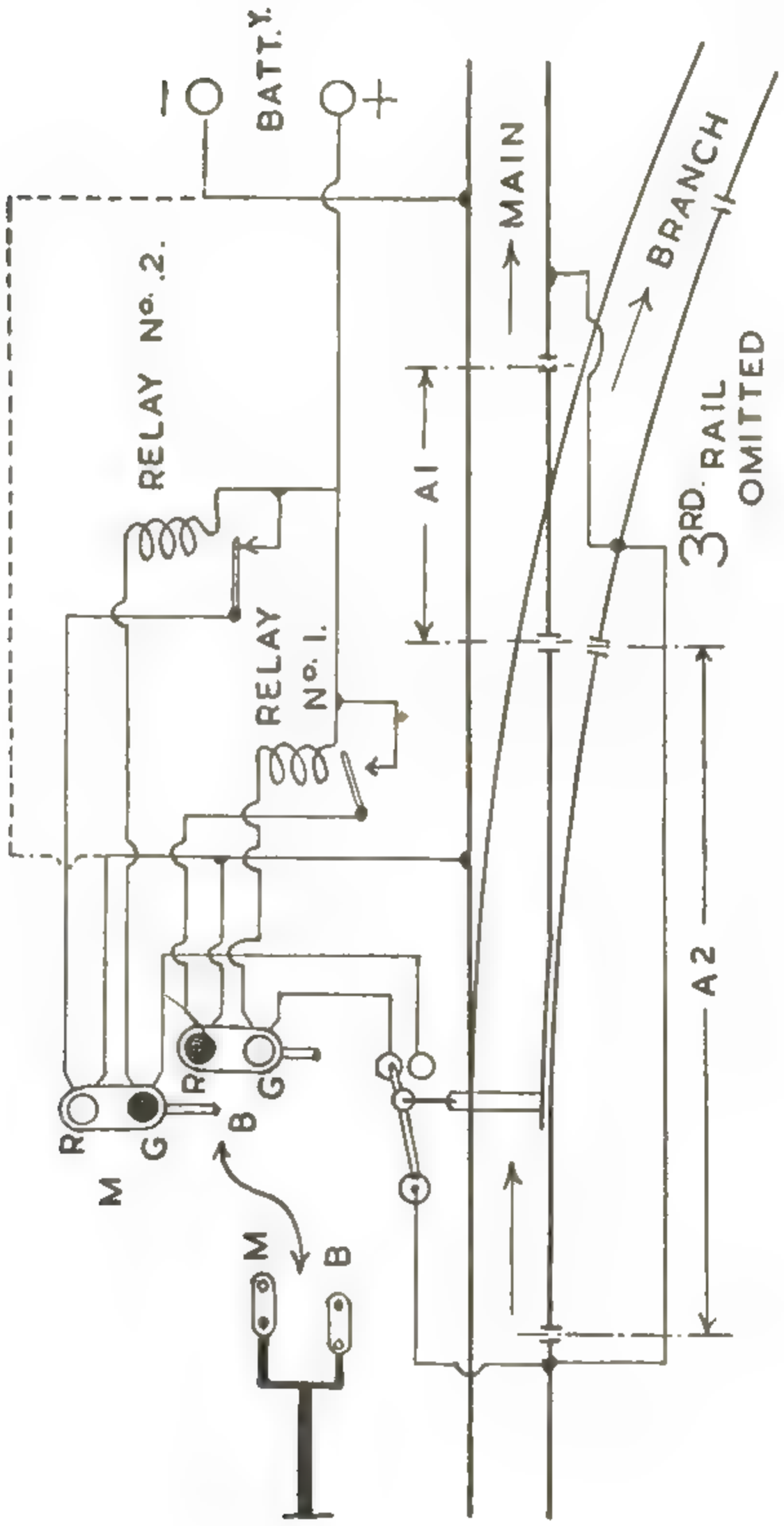


Fig. 46

the resistances can, if desired, be substituted by lamps of approximately the same resistance, which will do duty as control desk indicators.

Facing points may be wired to operate appropriate " splitting " colour-light signals in two different but very simple ways, one of which requires but one electro-magnetic relay, and the other two relays. In Fig. 45 is shown the wiring required by the first method, which is easy of installation, there being but one really important proviso,

viz, that the length of the dead section (*A*) must not extend (i.e., from *B* to *C*) longer than the wheelbase of the shortest vehicle likely to traverse the points. If it is possible to arrange matters so that the tongue of the point (*D*) does not make metallic contact with its stock-rail (*E*) when the point is set for main, then the dead section (*A*) can be

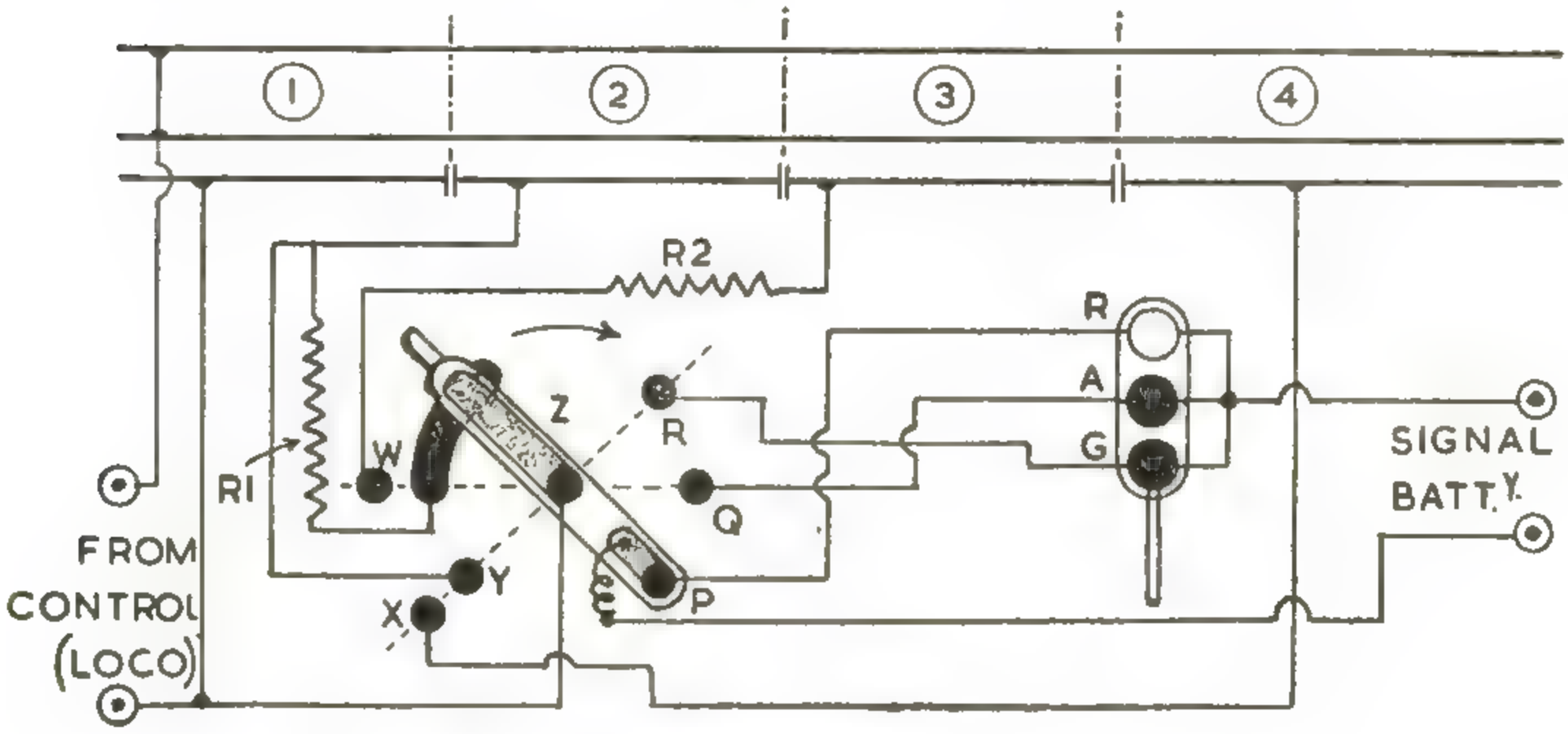


Fig. 47

dispensed with only the two-rail gaps at *F* and *G* being required.

The second method of operating a splitting colour-light signal is shown in Fig. 46, where it will be seen that a common signal power supply drives two magnetic relays according to how the points are set; and this system has the advantage that if the points are not fully over against their stock-rails, and the auto-switch thus in a midway position, the red lamp on both signal posts will light up, and the risk of despatching a train over incorrectly-set points is reduced—particularly if the signal lamps are indicated at the control desk.

The construction of the apparatus required for the realistic operation of three-colour light signals is slightly more involved than that entailed in the schemes already described, but the circuit shown in Fig. 47 will be found

to give all the indications required, whilst providing the added advantage of slowing down the trains when the amber light is showing, together with a final "stop" when the red light appears.

This system then, is one in which the traction power and the signals are mechanically interlocked over three consecutive sections by means of an extension arm on the signal switch by which the locomotive traction current

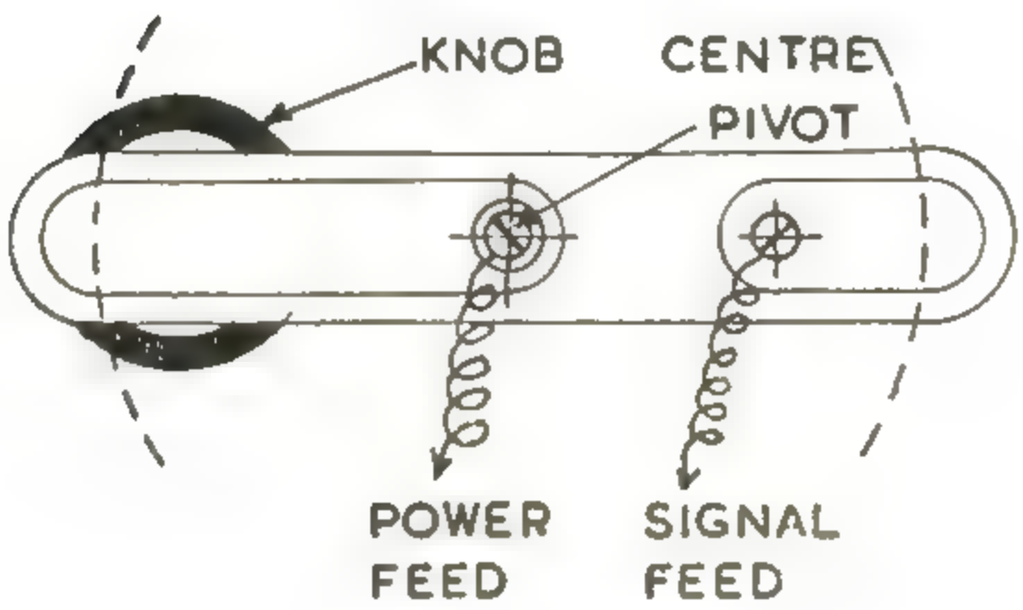


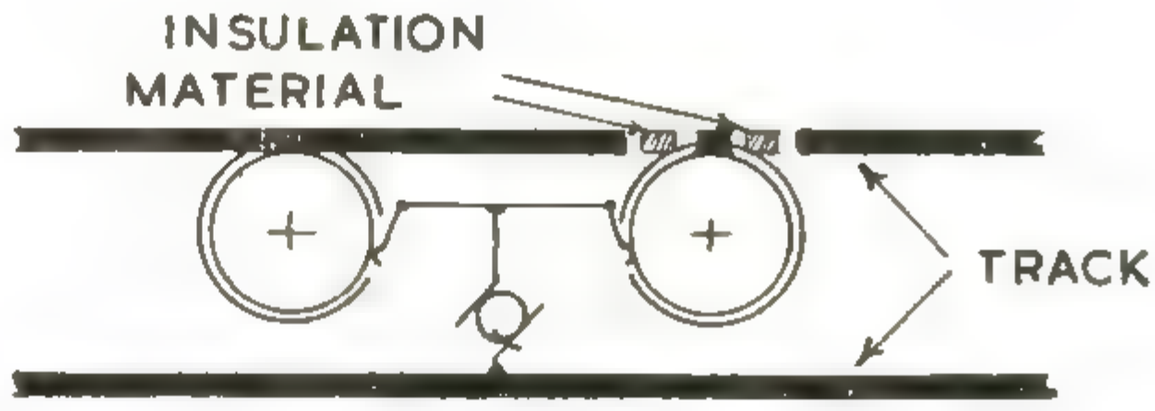
Fig. 48

is controlled. Each separate three-colour light signal is operated by a three-position rotary switch, of which the basic constructional details are shown in Fig. 48, from which it will be seen that the arm is composed of a piece of ebonite or even hardwood, from the centre to one end of which is screwed a strip of thin sheet copper or brass; from the other end of the arm another strip is fitted which extends nearly to the centre pivot. The object of these two strips is to carry the signal current (via one piece) and the traction current (via the other). Upon placing this switch-arm right side up, the switch-blade connected to the spindle slides over and makes contact with the studs *W*, *X*, and *Y*, as well as with the sector-piece (*Z*). This movement, (Fig 47), cuts down the current available to the locomotive by means of resistances *R*1 and *R*2, thereby reducing its speed eventually to zero. At the same time, the shorter switch-blade has

traversed the studs *P*, *Q* and *R*, thus allowing current from the signal battery or power-supply to illuminate either the green, amber or red lamp.

These two arcs of studs must be arranged on either side of the central switch-pivot in such a way that when the arm is in position *R*, the green lamp is alight and the locomotive has the same full voltage applied through all four sections (1, 2, 3 and 4) of the third rail and so travels at full speed. When the switch is moved to position *Q*,

Fig. 49



the amber light is illuminated, and the traction current applied to section 2 is reduced by resistance *R*1, irrespective of the fact that the normal speed controller is left at "full-speed." At switch position *P*, the red signal light shows, and section 1 carries full traction current again, section 2 has reduced voltage, and sections 3 and 4 are cut right out; thus bringing the train to a stop. The complete cutting out of both sections 3 and 4 prevents any chance of a locomotive-to-guard's-van collision should another train be standing at the signal between these sections. It is also essential that the signal post should be located at the gap between third-rail sections 3 and 4.

The determination of the exact resistances *R*1 and *R*2 is a matter for experiment, their values being in relation to the resistance of, and the current consumed by the locomotive motors. Variable resistances, wound with No. 24 or 26 s.w.g. "Eureka" or other resistance wire, will be satisfactory, and the correct values for any given motor can then readily be found by trial and error.

The operation of automatic signals on two-rail electrified

track presents many problems which do not exist when other methods of electrification are used. As both of the running-rails carry traction current at different polarities and varying voltages, neither rail can be used for the normal track-circuiting circuits already explained. The problem has to be approached from another angle.

On the insulated side of a normal two-rail locomotive, the driving-wheel rims are interconnected by a common collector brush, whereas every wheel on the insulated

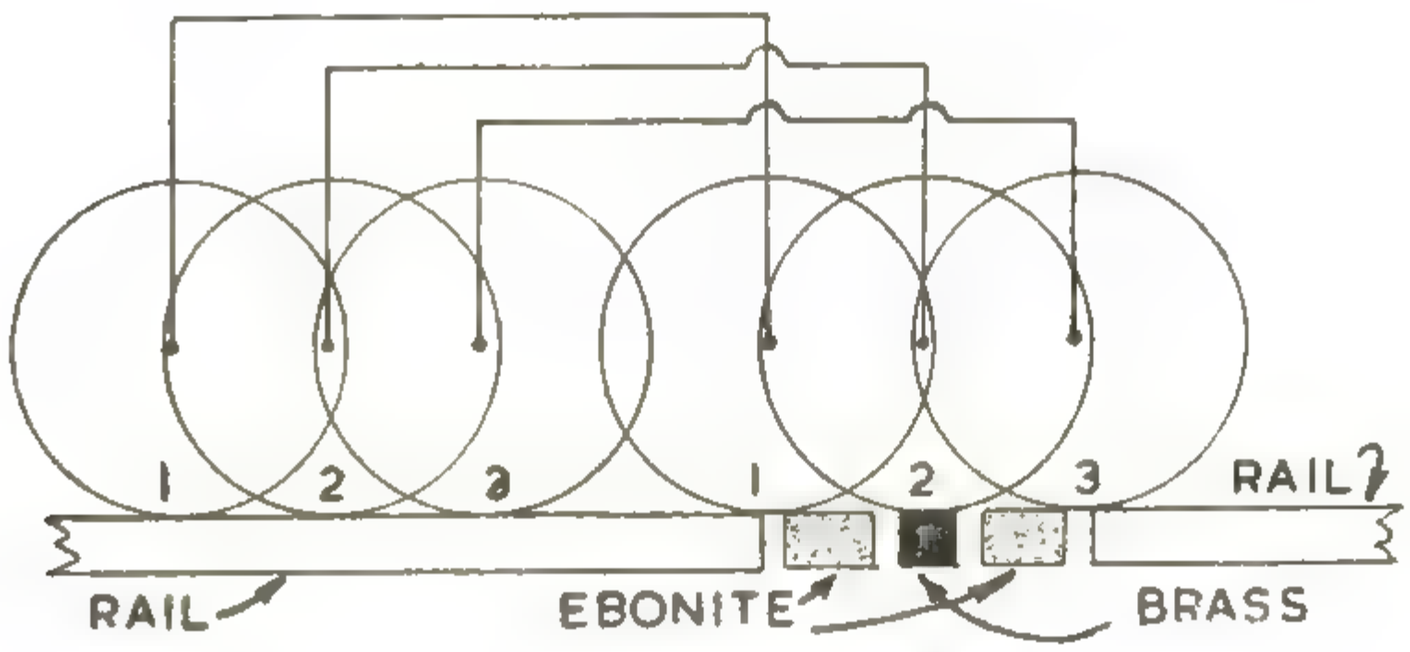


Fig. 50

side of a train has its rim insulated from every other wheel and from the metal-work of the vehicles. This difference is made good use of in the track-circuiting method shown in Fig. 49, wherein it will be seen that the locomotive, as it progresses over the isolated contactor, permits current to flow from signal battery to the isolated section of rail *via* the common collector which rubs on the flanges of the driving wheels. As no other wheels in the train have their treads interconnected, they pass over the contactor without connecting the running-rails (*C*) and the central section (*B*). They can touch together *C* and *A*1 or *A*2, but these being neutral pieces—entirely unconnected—no electrical contact is made. (See Fig. 50).

One such rail contactor is needed to move the signal to "off" and another to return it to "on"; as is shown in Fig. 51. It will be seen that a double bobbin (point-motor type) solenoid will be needed to operate the signal, one coil being used to move the latter to the "off" position

and the other to return to the arm to " on." The distance between the " off " contactor and the signal itself should be—in " OO " scale—about 2 ft., and the " on " contactor should be situated at about one average train's-length beyond the signal.

The signal motors, though of the point-motor type, need not be anything like so large as those used for working even " OO " points, the sizes given in Figs. 2 and 3

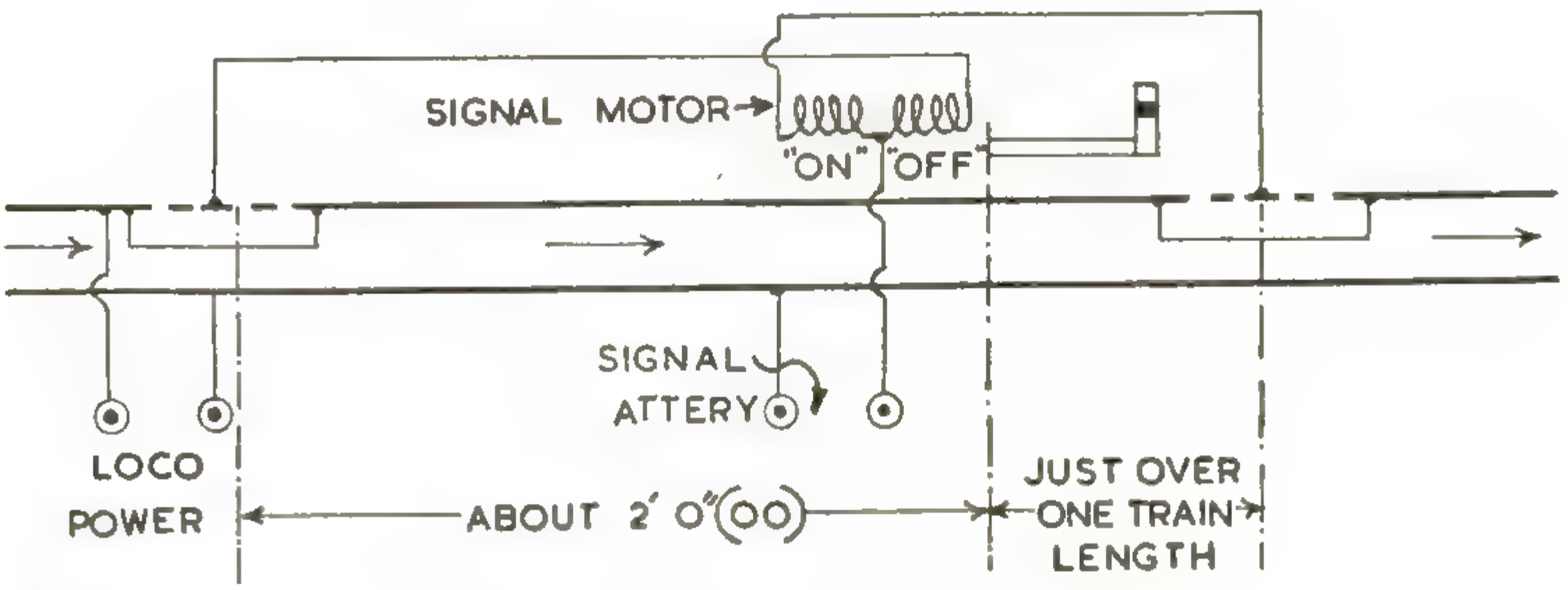


Fig. 51

will be found to give ample power to operate an average 4 mm. scale semaphore arm. Each bobbin should be wound with as much No. 30 s.w.g. enamelled or single cotton-covered copper wire as can comfortably be accommodated within bobbins of the approximate size shown. In bobbins of such a small size there is no real need to fit cheeks, the wire being wound direct on to the solenoid tube; the latter consisting of a short length of $\frac{3}{16}$-in. brass. The complete motor can be mounted at the base of the signal post by clips as shown, or can be sub-baseboard mounted in horizontal style, as desired. (Fig. 52).

When working with such small bobbins, a signal-operating supply voltage of 4V will be found quite adequate this being conveniently derived from a dry battery of the " cycle-lamp " type. Care should be exercised to ensure that at no time a continuous flow of current is permitted

to flow through the coils, for they would readily burn out under such treatment.

It may be mentioned that though this contactor arrangement gives two impulses as the locomotive passes over it (one on entering and one on leaving both the " off " and " on " contactors) the signal will only operate on the first impulse, for the solenoid armature has already been moved by that impulse, and therefore cannot be moved in the same direction again.

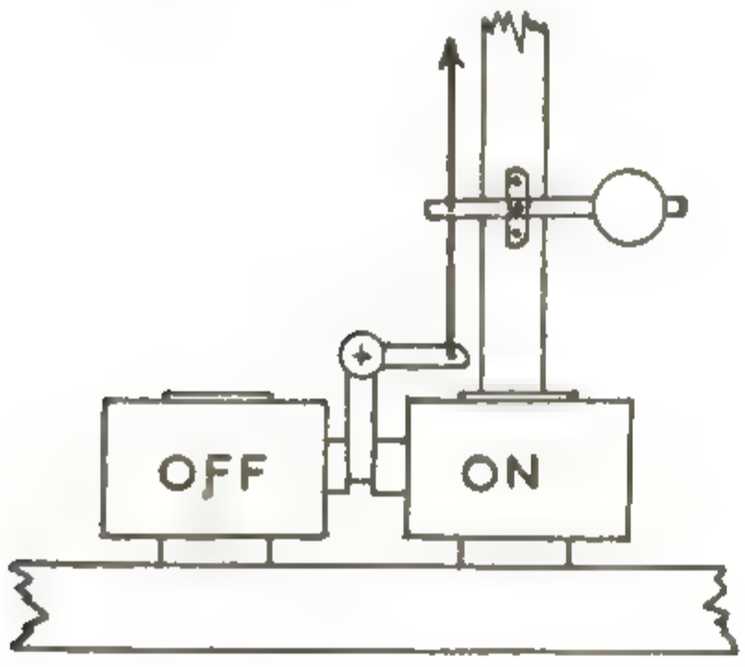


Fig. 52

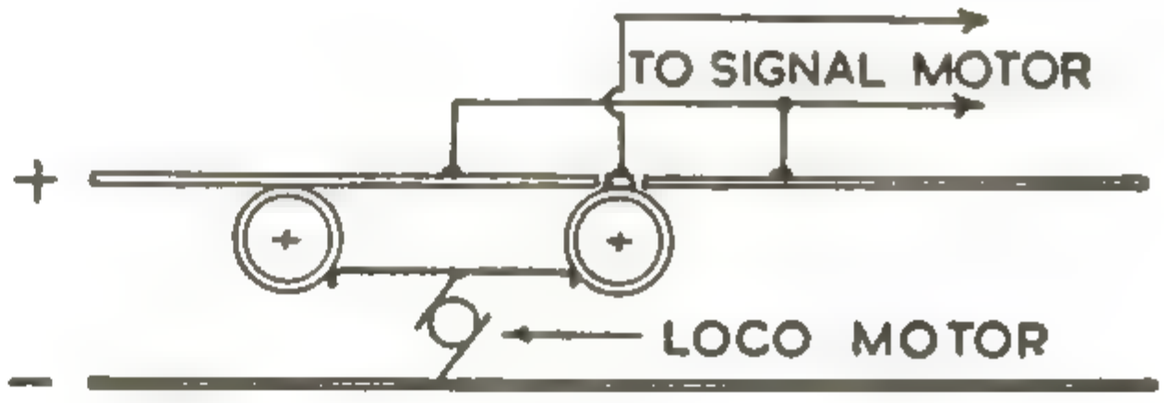


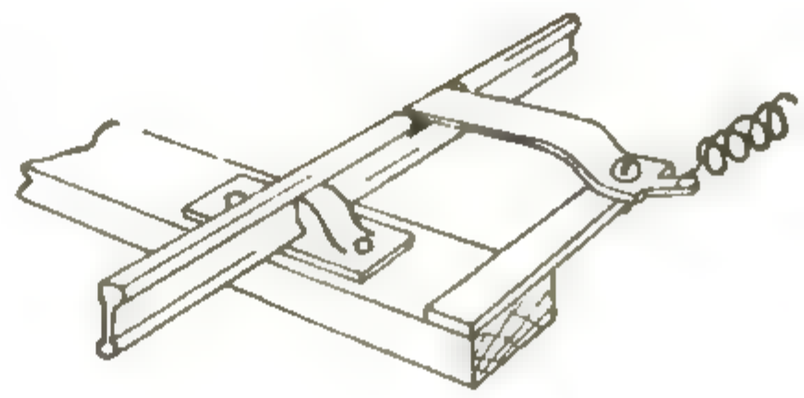
Fig. 53

If there is no objection to the " clicking " of the signal motor as every pair of wheels in a train passes over the contactor, the latter may be simplified as shown in Fig. 53, in which only one isolated section of rail about $\frac{1}{16}$ in. long is used. This method is also useful for layouts which are run with locomotives having single driving-wheels, for the signal circuit is completed by the rim of *any one wheel* contacting the continuous rail and the isolated piece.

Another simply-made contact device is that shown in Fig. 54, which consists of a piece of very thin strip brass bent as shown, and resting in a gap in the running-rail, *but not touching*. The thickness of this strip and its flexibility should be such that a heavy locomotive will depress the strip into contact with the rail, whereas the relatively lighter wagons and coaches will not bend it sufficiently to make contact.

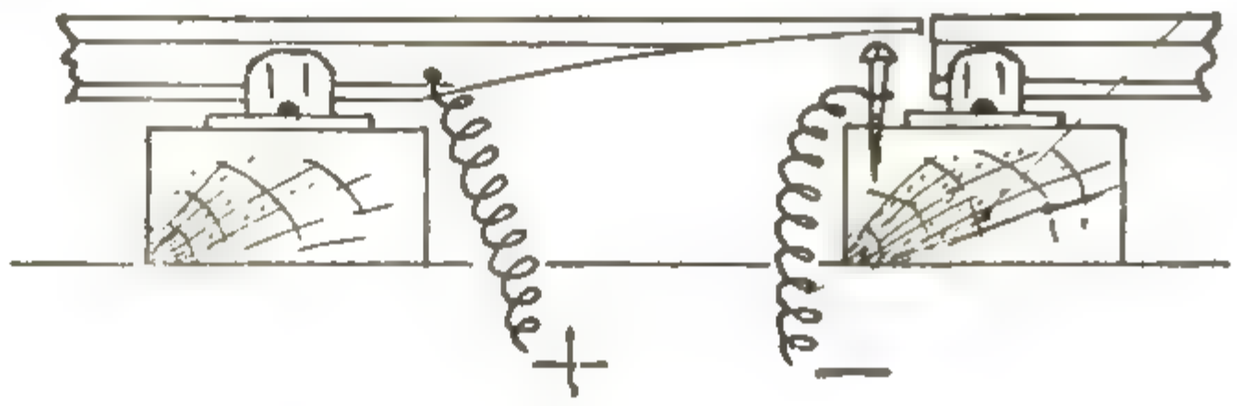
For " O " gauge steel or brass track, either of the contacts shown in Figs. 55 or 56 will be found suitable, the first

Fig. 54



working on the principle of vertical rail deflection, and the second upon that of a single-bladed catch-point with a lightly-sprung blade. The contact of type Fig. 55 may be so balanced that only a locomotive or other heavy vehicle will work it, and the contact may be easily made adjustable for pressure; but the catch-point type will, of course, operate with every pair of wheels passing over it. Type Fig. 55 is, therefore, to be preferred for general use.

Fig. 55



When using any of the types of contactor (Fig. 49, 53, 54, 55 or 56) described, it must be understood that point-type motors will be needed to work signals, and that two contactors (one "off" and one "on") are necessary for each signal.

There are other methods of signal operation which can be used on two-rail electrified track, but they incorporate the use of relays and resistances, and are far more delicate of adjustment than the types shown, the only pre-requisite of the latter being the use of double-coil motors and one or other of the rail contactor types described; all of which are easily made and capable of long-continued use if carefully adjusted in the first place.

The types of rail contacts explained by no means exhaust all possibilities, but will go far to show that, with a little inventive skill and perseverance, the reader will be able to originate other schemes when once the use of the double-bobbin motor as a *signal*-operating device has been accepted.

There is another method by which points and signals may be operated, and which entails the use of but one

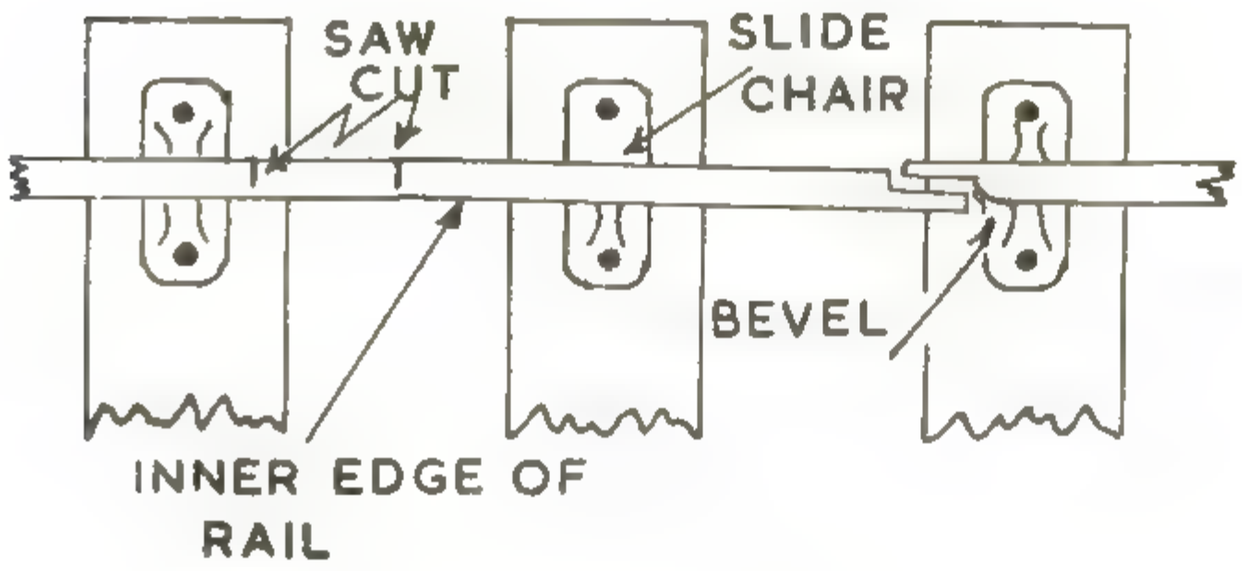
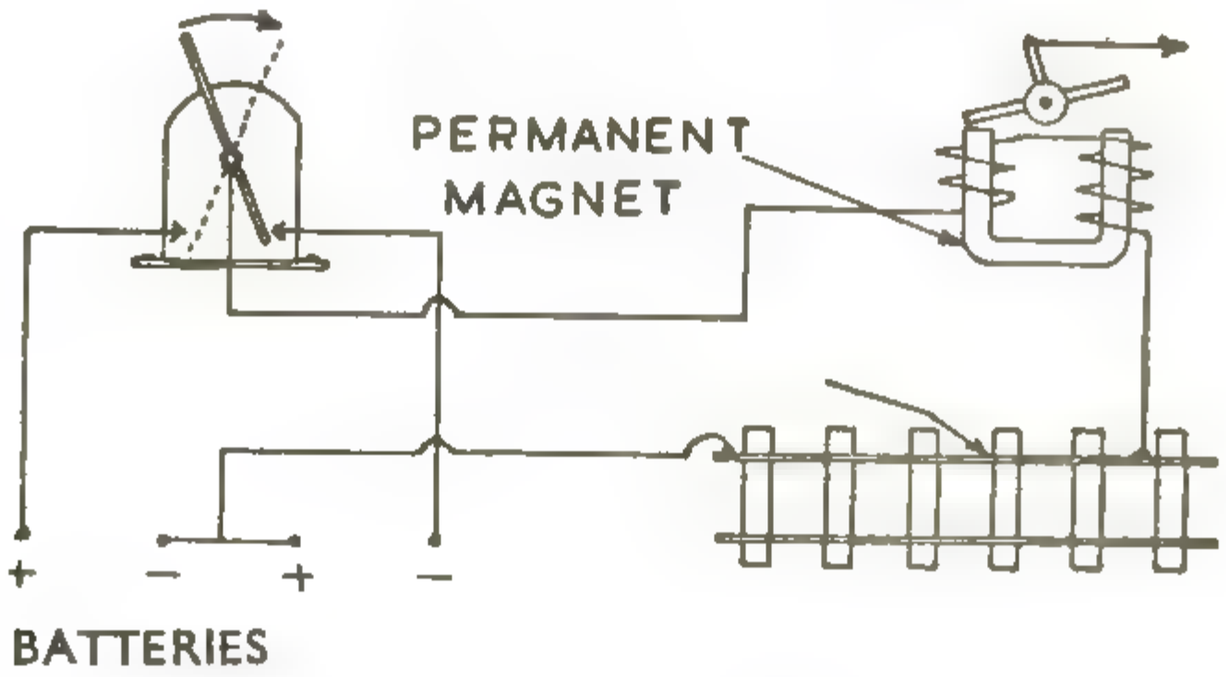


Fig. 56

electric wire from the cabin. It also requires the use of a small magnet, such as those to be found in a discarded "OO" motor. This system works on a polarised magnet and two 1½ V dry-cells, as shown in Fig. 57, in which the two batteries are connected at *B*1 and *B*2, and the manual lever (*SL*) connected to the polarised motor by one wire; the return is taken *via* a continuous running-rail (*C.R.*). The motor armature is pulled toward either magnet pole-piece according to the direction of flow of the current, which is determined by which battery is switched into circuit by the lever. It will be noted that the batteries are connected positive to negative in the same way as that used for constant polarity traction power-supply.

It may be said that any of the foregoing systems will operate when used with the stud-contact method of track electrification, and those which do not depend for their power-supply on traction current (Fig. 33) will work on clockwork or steam-operated layouts. Most systems can be effectively run from 2, 4 or 6 V dry batteries if the layout is not in constant use, and such batteries will give quite

Fig. 57



long periods of operation without replacement if a main switch is fitted by which they can be *completely* isolated when the railway is not being used. It should not be considered that this latter refinement is suggested lightly, for it is a real money-saver when dry batteries or small accumulators are used as a source of signal operating current.

CHAPTER FIVE

THE essential feature of any system of point-signal interlock should necessarily be that it is impossible for a signal to be pulled "off" if the facing points that it covers are incorrectly set; and strictly speaking, to follow basic prototype practice, it should be possible for a "driver" to run past a signal in the "on" position. This formulates the ideal, and eliminates the ideas which stipulate the working of points and signals from one lever, by which method there is frequently one signal (at a facing junction) showing in the "off" position; even when no traffic is approaching.

In Fig. 59 is shown the circuit necessary to produce the aforementioned conditions; it entails the use of four signals, two levers (push-pull type), and one point-lever, the latter working a double solenoid point-motor. It will be seen that the feed to the "off" studs on the signal levers is *via* the point-lever, the latter passing on to the signal-feed studs *X* or *Y* after it has made contact to the signal motor. The normal position for the signal lever is central, as shown in the diagram.

It will be appreciated that if the point-lever is not pulled or pushed right "home," the signals cannot exhibit a green indication, for both red and green lamps go out. Moreover, if the points are set correctly, then the appropriate green indication will be given for that road, with red on the other track and in the next section ahead.

Two power-supplies are used, one at about 2 V for the

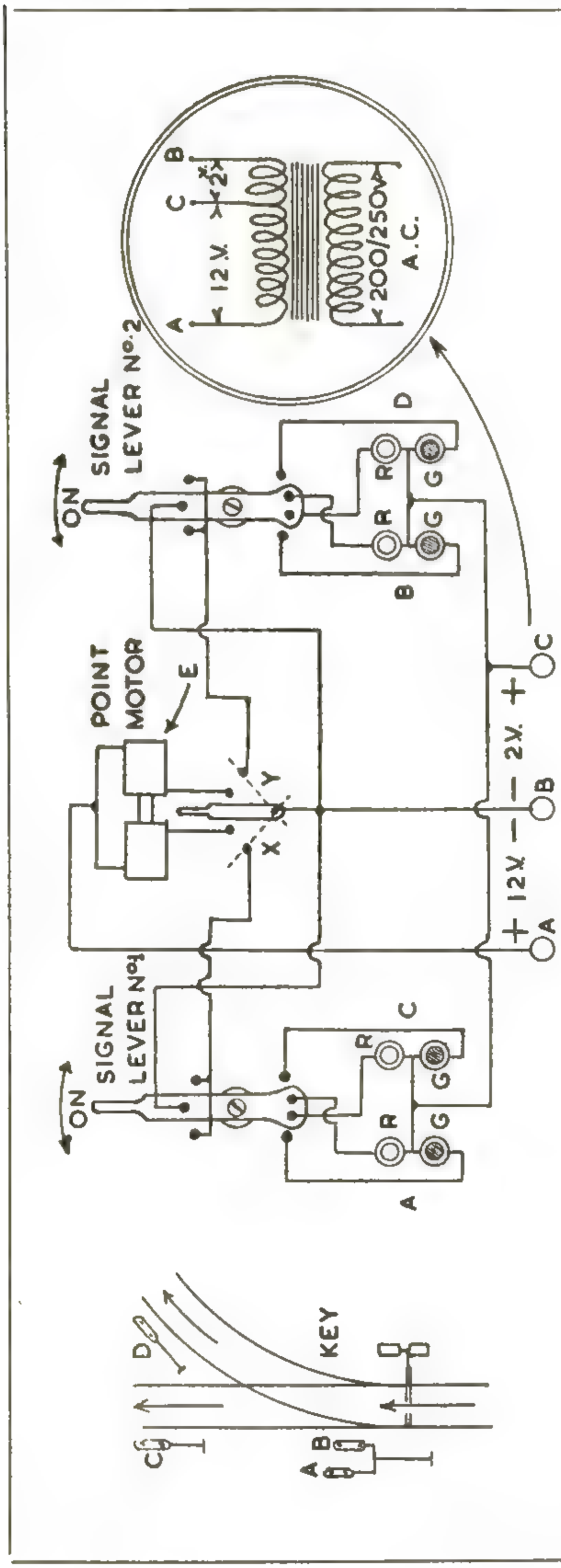


FIG. 59

FIG. 59B

FIG. 58
(KEY TO FIG. 59)

signal lamps (if colour-lights are used) and the other at 6 or 12 V for the signal motor. These supplies are fed to the terminals *A*, *B*, and *C*, and if desired a tapped transformer can be connected, as shown in the inset sketch,

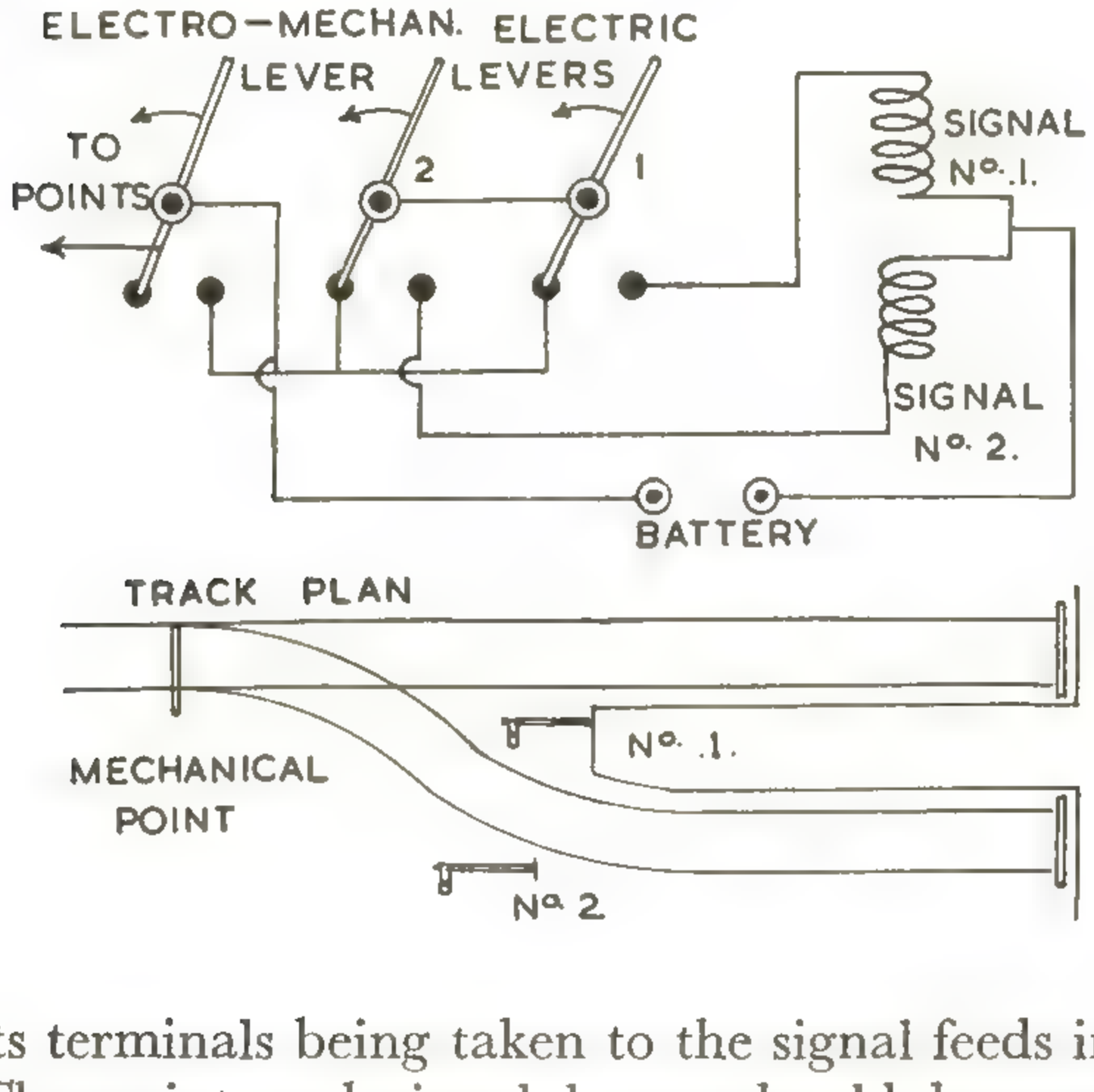


Fig. 60

its terminals being taken to the signal feeds in letter order. The point and signal levers should be made from thin brass strip and arranged to wipe their respective contact studs as shown in Fig. 59B, which is self-explanatory.

Another simple electro-mechanical lever interlocking scheme is shown in Fig. 60, which can be used to control the exit from a platform bay road or siding. In this case, the point is operated mechanically by a box lever, to the tail of which a contact is taken, whilst the signals are solenoid operated by levers 1 and 2. It will be seen that neither of the signals can be pulled "off" unless the point is correctly set for the proper road, and that only one or other signal can be worked at any given operation, as the circuit to the signal motors is only completed when No. 1 is pulled and No. 2 not pulled. This system is not automatically operated by the train itself, but is manual.

A study of Fig. 58 and 60 will show at once how much more easily achieved is interlocking when carried out electrically, and how its principle may be applied readily to even clockwork and steam operated layouts, the source of electric signal power being derivable from dry batteries or primary cells. Not only so, but by the use of simple double-pole single-throw switches of any standard pattern* instead of the more orthodox signal "levers," quite a large layout may be effectively operated from the signal-box without any great expense. In simpler set-ups, even ordinary "bell-pushes" may be used with success.

The simple electrical interlocking possible at a double junction signal-box (Fig. 61) is shown in Fig. 62, where it will be seen that the two master levers are those moving the points. Lever *P*2 feeds signal levers 5 and 6 when in the "unpulled" (normal) position, and levers 7 and 8 when pulled. Similarly lever *P*2 † feeds signal lever 9 when normal, and lever 11 when pulled. Signal levers 4 and 10 may be pulled irrespective of the position of the points, and draw their power supply *via* the wire "*X*," which runs straight back to the main feed terminals, *A* and *B*.

By further elaboration on the circuit of Fig. 62, it is possible to arrange interlocking to suit any given layout or part of a layout, it being necessary merely to wire the levers (or switches) controlling the signal motors in series (i.e., one behind the other—electrically) so that one lever is ineffective unless the other is pulled. (*cf.* Fig. 60, which shows this scheme in its simplest form.)

The introduction of double-pole double-throw switches instead of the single-pole double-throw type shown in Fig. 62, it becomes possible to arrange back-locking, so that signal No. 9 could not be pulled "off" with No. 11 ;

*The writer has used banks of twelve switches, as purchaseable second-hand under the name of "radio push-button units" for this purpose. The multiple spring-trip bar should, however, be removed, so that each push-button operates independently.

†Lever *P*2 (Right hand) in Fig. 62.

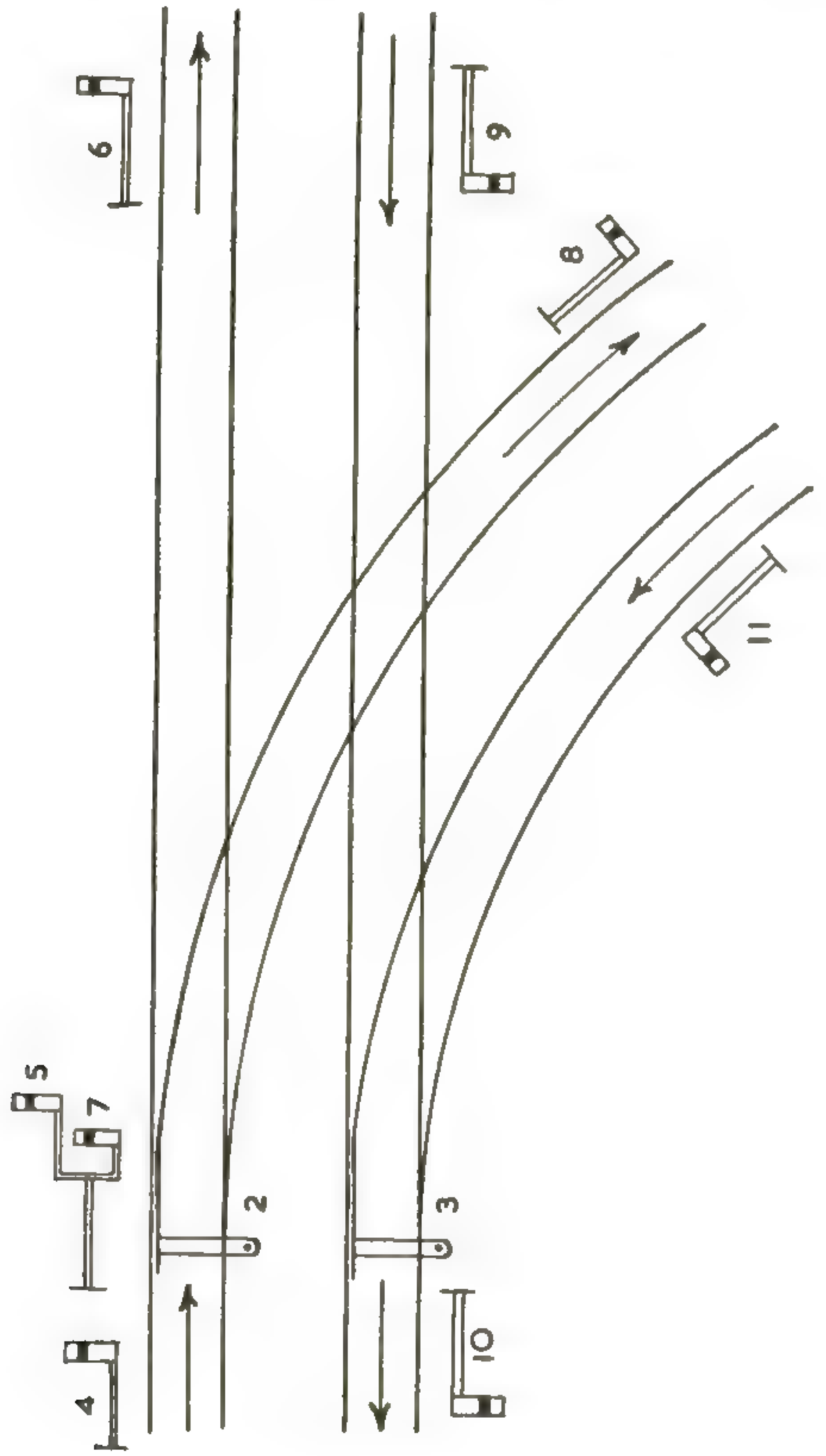


Fig. 61

nor could No. 7 and No. 9 possibly conflict in their indications. It is, however, very important that, when arranging an interlocked electric frame, the signals themselves should be correctly placed with respect to each other and to the points they control. This subject is outside the scope of the present work, but has been fully dealt with by the writer elsewhere.*

* *Model Railway Signals*, Messrs. Percival Marshall Ltd., London. (See Chap. VII, *et seq.*) Other methods of interlocking are also discussed.

AND POINT OPERATION

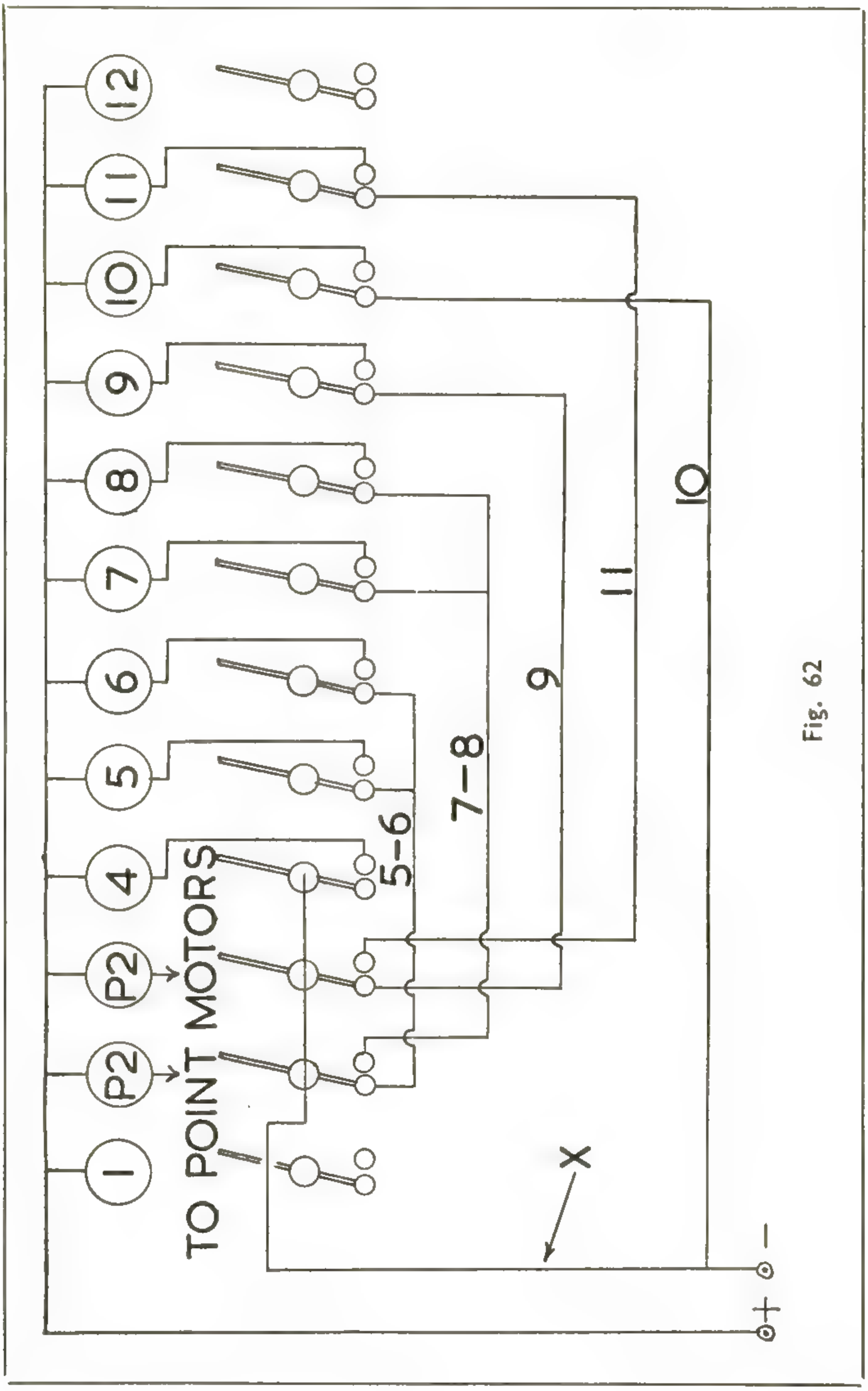


Fig. 62

In model work, distant signals are frequently dispensed with as they do not add any useful function to a layout. The sections are also usually so short that there is no room for their inclusion, but the method of electrically slotting a distant arm, so that it requires the co-operation of two signalmen to bring it to the " off " position, is very simple indeed, as will be seen from Fig. 63. The distant lever only works when home signal is " off." Putting the home

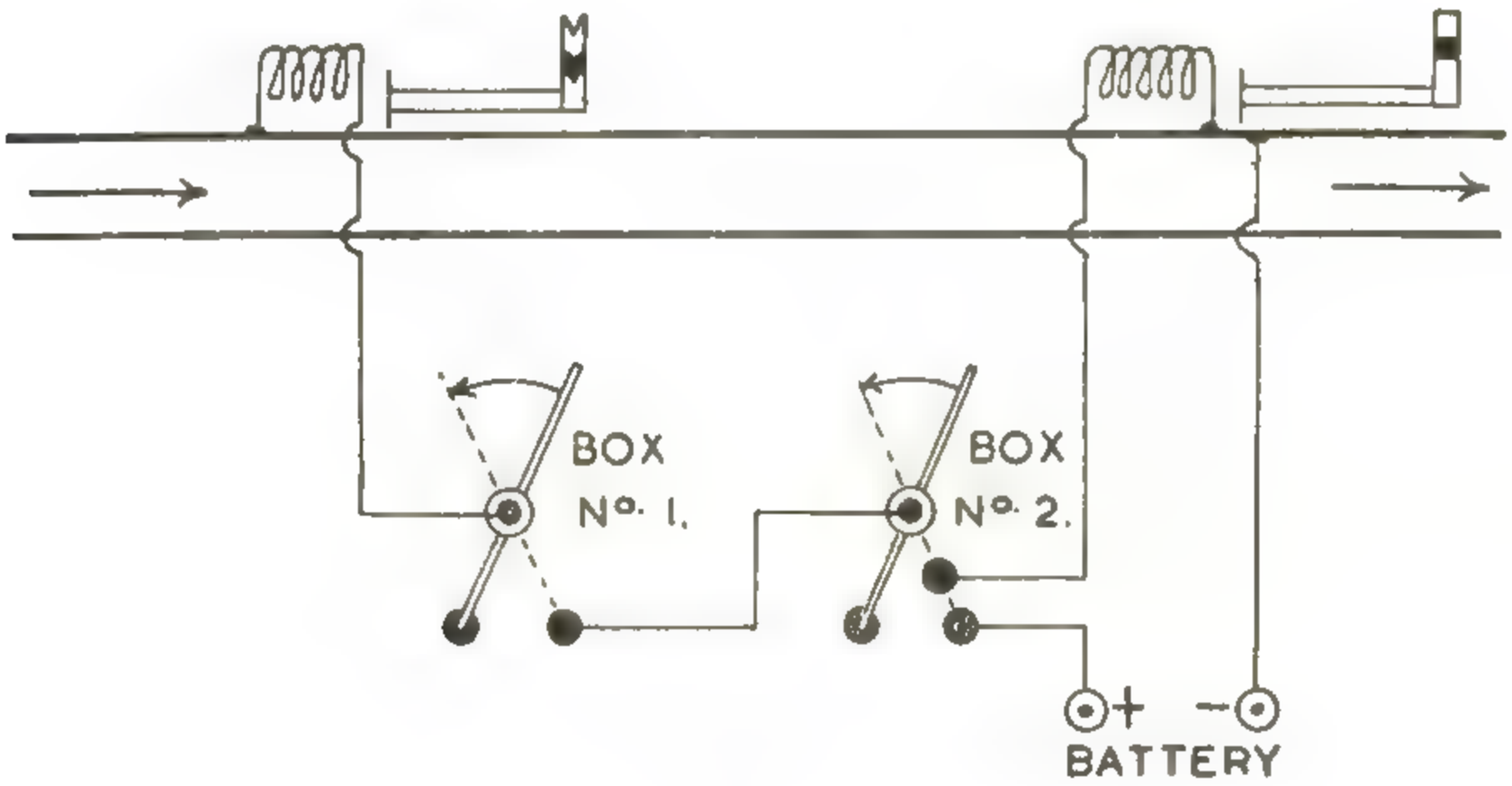


Fig. 63

signal " on " also puts the distant signal " on." The home signal cannot work until the distant lever in box No. 1 has been returned to normal. In this circuit, the levers in both boxes No. 1 and No. 2 must be pulled before the signal motor will be energised. If the return from the signal motor to the battery is made *via* one of the running-rails, the rail which is *not* track-circuited must be chosen. If neither rail is used as a return, then a wire must be taken to the motor from the supply source, as shown dotted.

The right-hand double junction shown in Fig. 64 can be interlocked electrically by the simple use of single-pole double-throw and double-pole double-throw switches, including the back-locking of levers 5 and 2, and 6 and 9, this being accomplished by the use of double throw switches for point levers 5 and 6, and signal levers 2 and 9; it

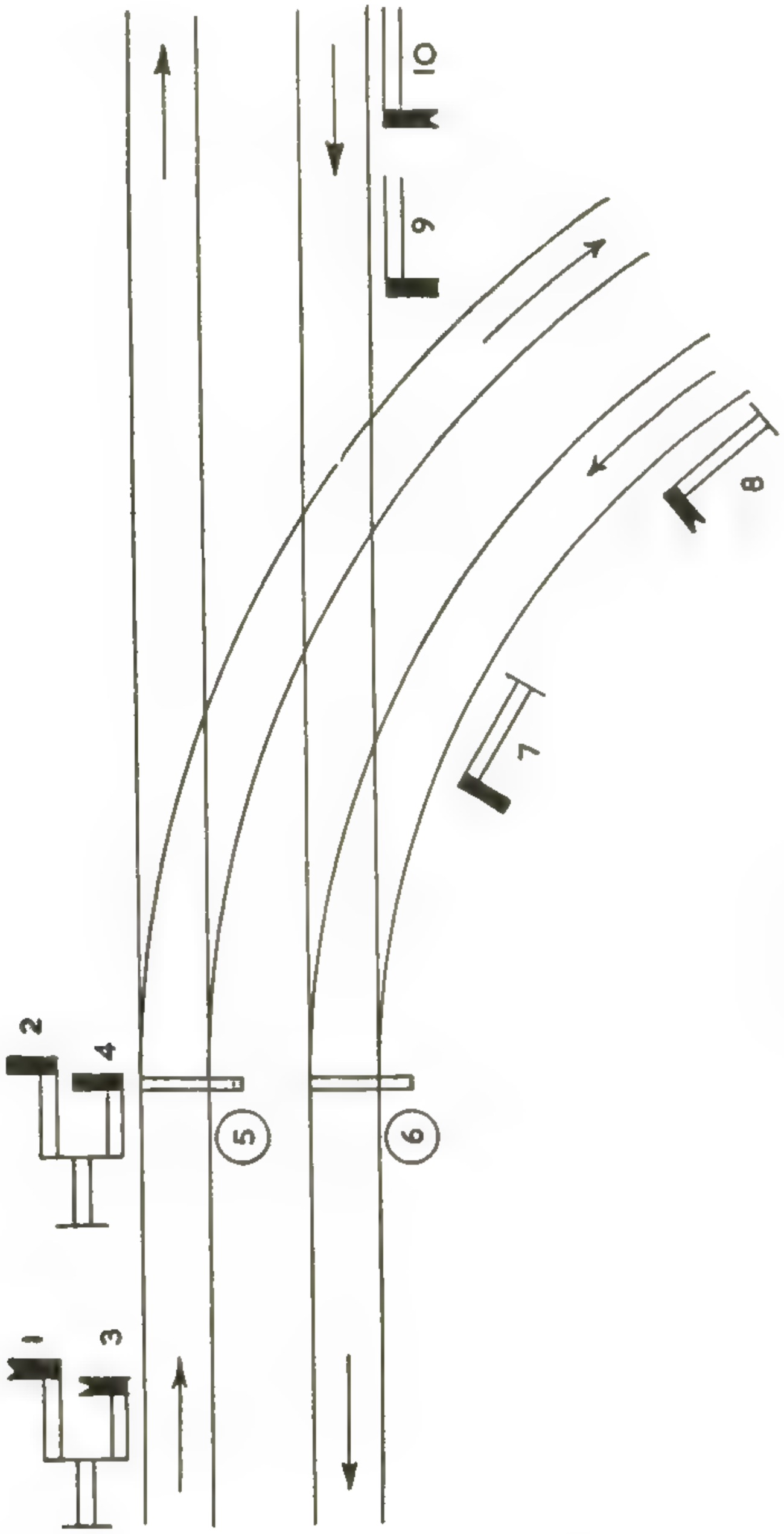
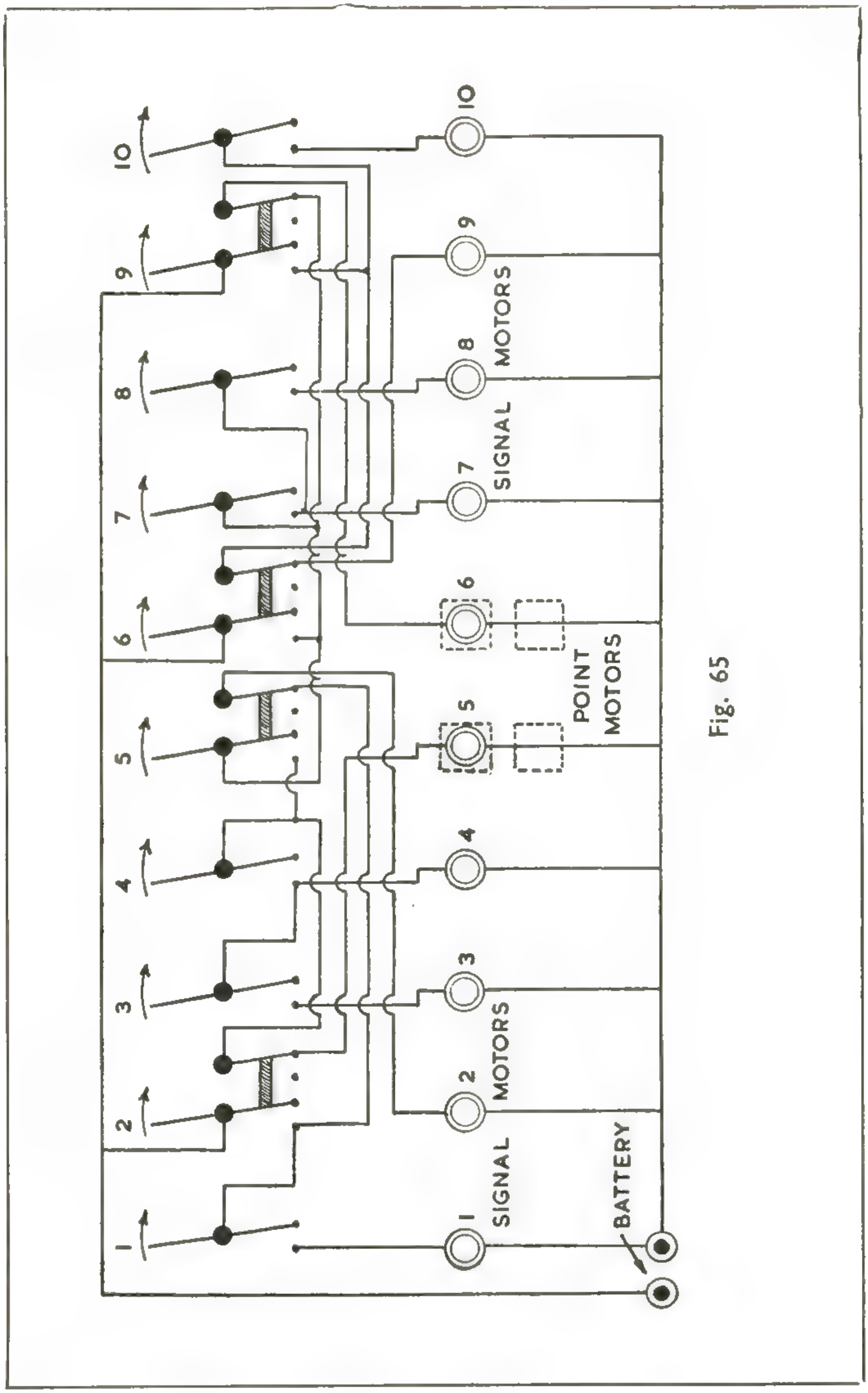


Fig. 64

prevents lever 2 working its signal if lever 5 has been pulled, and *vice versa*. Lever 9 will not operate its signal if lever 6 has been pulled—and *vice versa*. (Fig. 65).

Point-levers 5 and 6 have only their signal interlocking contacts shown on Fig. 65, those for the point-operating


10
9
8
7
6
5
4
3
2
1
9
8
7
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4
3
2
1
SIGNAL MOTORS
POINT MOTORS
SIGNAL MOTORS
BATTERY

Fig. 65

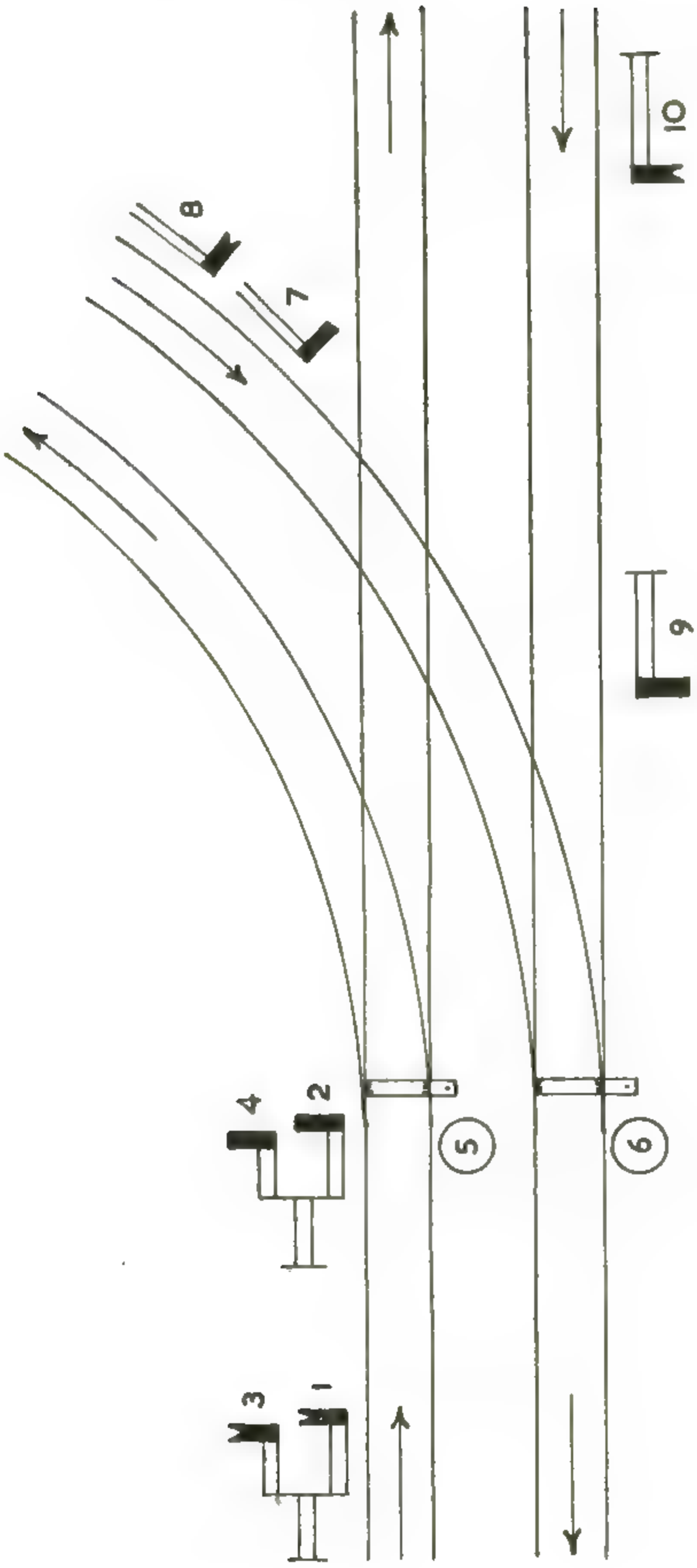


Fig. 66

solenoids are fitted as extra, unless the points are connected to the switches or levers by mechanical rodding.

In the diagram it will be seen that the "lead" levers (i.e., those standing "unlocked" in a mechanical frame) are Nos. 2, 6 and 9. No. 5 cannot operate its points until the down points (6) have been set to branch. (This locking

will not, however, prevent a down main-line train over-running its signal and colliding with an up train turning out on to the branch line.) Point-lever 6 locks 10 and 9, and also unlocks the down branch signals 7 and 8.

Should there be an up main-line train running at the time that the levers are in the positions mentioned, signals 1 and 2 are free, but directly 2 is pulled off the points are "locked" against movement; and, therefore, the branch signals 3 and 4 are also locked against movement. The main-line splitting home signal (2) locks the up points (5), which in turn lock 3 and 4. The "key" lever is No. 6, for it is in the middle of the frame and governs every other lever.

The locking circuit of a left-hand double junction is similar to that of a right hand one, but there is one point of difference which alters the locking functions considerably. Such a junction is shown in Fig. 66, where it will be seen that point lever 5 is the "free" one, and must be pulled before 6, the latter lever locking 5 when that is pulled over. This prevents an up train cutting into a down train from the branch, even if the up train over-runs its signal. (See Fig. 67).

In the interlocking diagrams (Fig. 65 and 67) it must be understood that where the term "locked" is used (as applied to mechanical locking-frames), it is intended to imply that if a "locked" lever was pulled, it could not operate its signal because no current was being fed to that lever by the other lever by which it was "locked." Thus, in Fig. 65, lever No. 1 is "locked" by and fed from No. 2; and lever No. 3 is "locked" by and fed from No. 4, which again is "locked" by and fed from No. 5, which is finally "locked by and fed from No. 6."

Once the basic principle of electric lever-frame (or switch) locking is grasped, it will be found quite simple to so arrange single or double-pole change-over switches to enable any number of forward and back-locking movements to be carried out by continued simple wiring, the finished

AND POINT OPERATION

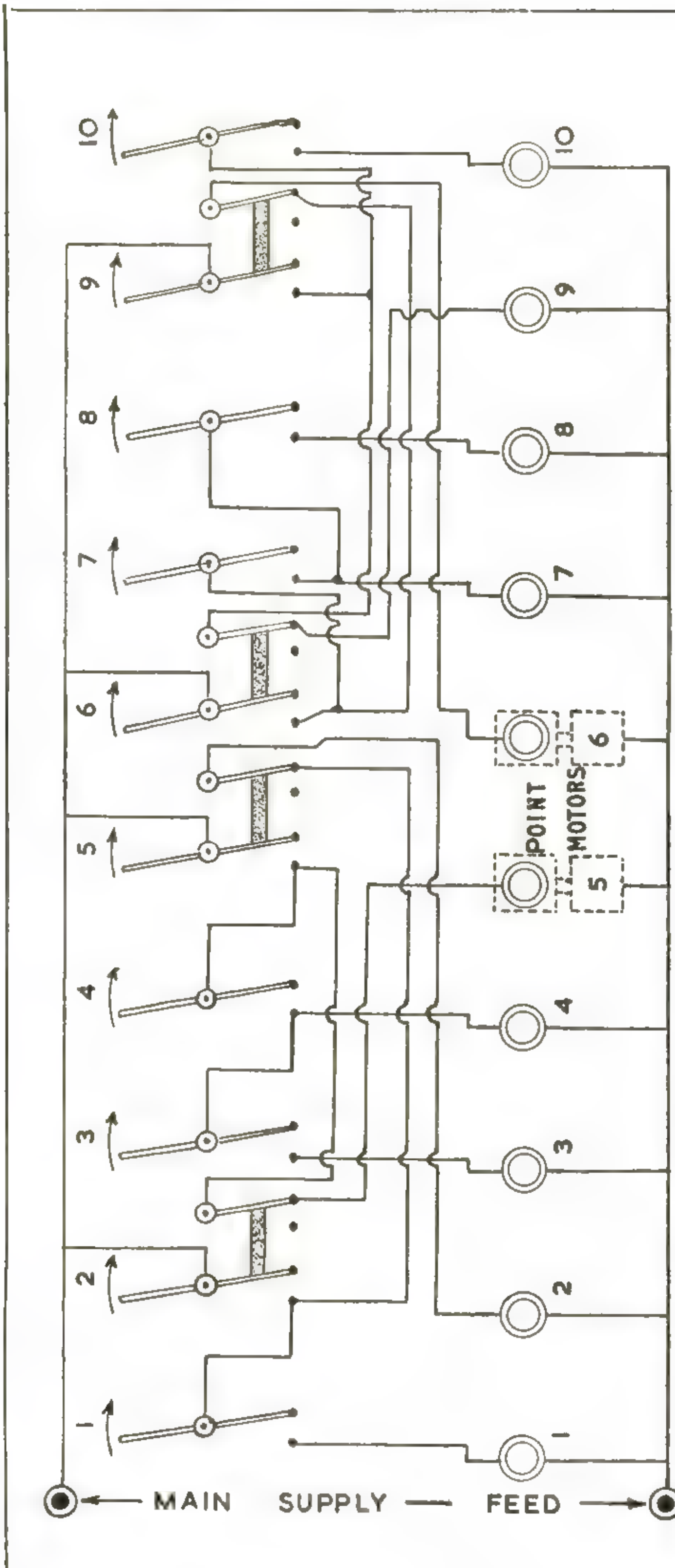


Fig. 67

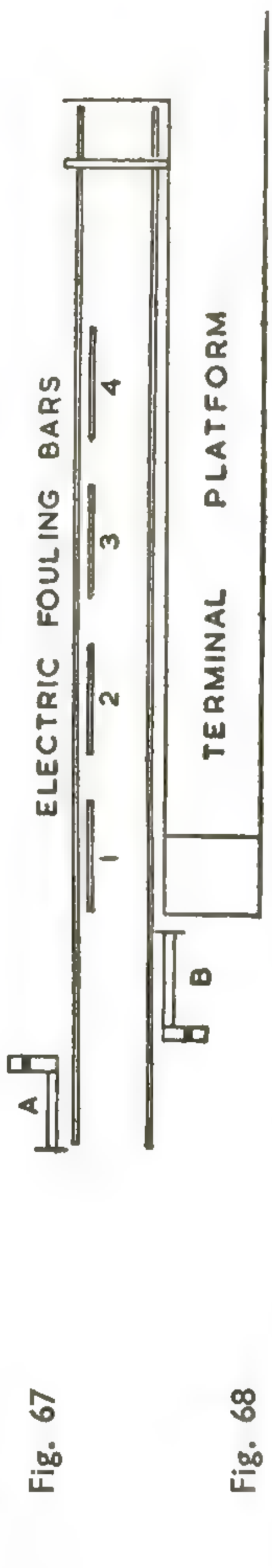


Fig. 68

frame or control desk being built up little by little from a well planned diagram, drawn along the lines of Figs. 65 and 67, together with a point and signal plan of the portion of the layout being signalled—as in Figs. 64 and 66. There is, however, one great mistake which the beginner in the art of signalling is very apt to make unwittingly and it

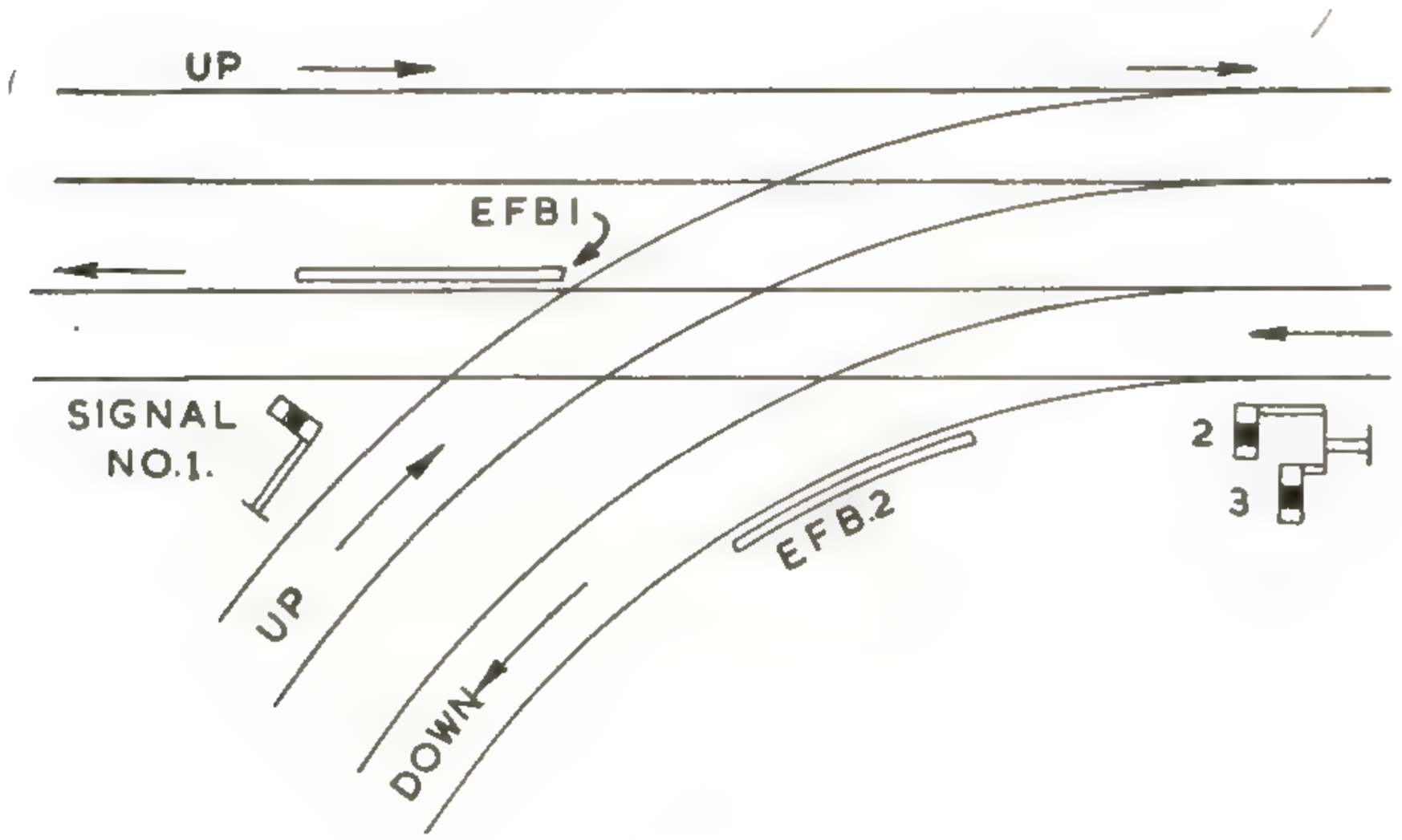


Fig. 69

usually consists of locking up a section of layout—or a station area—so completely that hardly a train movement is possible by anyone who has not " grown up " with the layout. Only sufficient locking should be provided to give adequate protection to the more general train movements, so that the two vitally interesting operational features given to model railway owners can be enjoyed to the full.

However, from the foregoing ideas the reader will be able to make his own selection as to the system upon which his layout will be signalled by power, for most of the arrangements noted are capable of being either simplified or extended to suit any particular circumstance; but in every case the apparatus has been designed to give the utmost satisfaction at the lowest possible cost. Thus,

neatness of design has, at times, been sacrificed to ease of construction, simplicity of operation, and low cost.

Another interesting application of electricity to the realistic signalling of model railways is that of electric fouling-bars, which may be employed for a variety of purposes, such as the protection of platform roads in stations, or of the tail of a train at a double junction. Examples of these two uses are depicted in Figs. 68 and 69 respectively. In the case of Fig. 68, the fouling-bars are placed at intervals, so that even an isolated vehicle is sure to depress one of them, and so give an indication to the signalman. The double junction shown in Fig. 69 shows how fouling-bars are placed so that the last vehicle of a train leaving on the down branch line must be clear of E.F.B.2 before signal No. 2 (down main) can be pulled "off." Similarly, the last vehicle of a down main-line train must be clear of E.F.B.1 before signal No. 1 (up branch) can be cleared.

It will be appreciated how simple it is to arrange sprung or balanced bars, which are arranged to stand normally flush with rail level, so that they may be depressed by the flanges of the wheels of a vehicle. The length of each bar is such that the longest vehicles will pass over (in a train) without allowing the bar to rise. The bar, in tilting operates an electrical contact-breaker which breaks the power circuit to the appropriate signal motor, thereby rendering it in-operative, even if its lever is pulled.

The great feature of the balanced or sprung fouling-bar is that it can be fitted irrespective of the track-circuiting as its contacts are entirely independent of both traction and track-circuit power supplies; but, of course, it is possible to use the non-track-circuited rail as a return path from the fouling-bar contacts.

In cases where signal boxes are very close together (and they often are in model practice) and there is the chance of a long goods train standing at the home signal of one box, whilst reaching back almost to the starting signal of the box

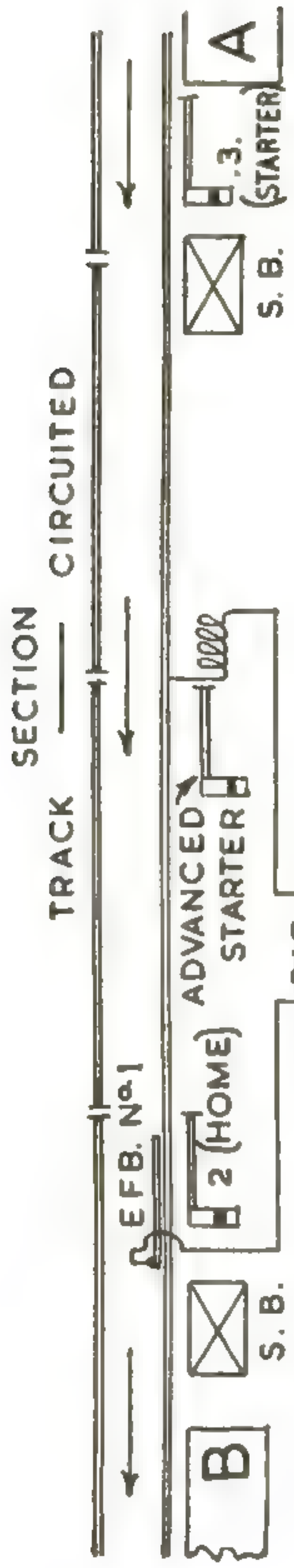


Fig. 70

in the rear; it is a good idea (often done in prototype) to place an electric fouling-bar ahead of the home signal to act as an overlap. (Fig. 70). In this case E.F.B. 1 locks signal No. 1, which cannot be pulled "off" for another train to proceed from signal No. 1 to No. 2 until the last vehicle of the first train has pulled clear of the fouling-bar.

In Fig. 70 is also shown the approximate position of the normal track-circuit signalling rail-breaks which, it will be seen, are on the rail opposite to that used as an "earth" return for the fouling-bar circuit. If desired, another wire may be used instead of the rail as return.

Where traffic speeds are slow, a short ramp about $\frac{3}{4}$ in. long must be made at each end of the balance-bar, but with high speeds, anything from $1\frac{1}{2}$ in. to 2 in. is necessary; otherwise, vehicles may be derailed by the shock they sustain when passing over it.

At busy stations a train often stands at an adverse signal for some time without being observed by the signalman. If normal track-circuiting is not in use, and the signals not entirely automatic, a "train-waiting" indicator is a very useful and simply-made adjunct, being, in fact, a balance-bar similar to those used as fouling-bars, which, on depression, sounds a buzzer in the signal-box. This indication is stopped, and the circuit broken on pulling

"off" the signal at which the train is standing. (Fig. 72).

In real practice, of course, a hand-operated plunger—in a box fixed to the signal-post—may be operated by the fireman or driver of the waiting train, who depresses the plunger and thus operates an indicator in the signal-box. An audible return indication is given at the signal-post, showing that the warning has been received. If no indication is returned from the signal-box, then rule 55 must be

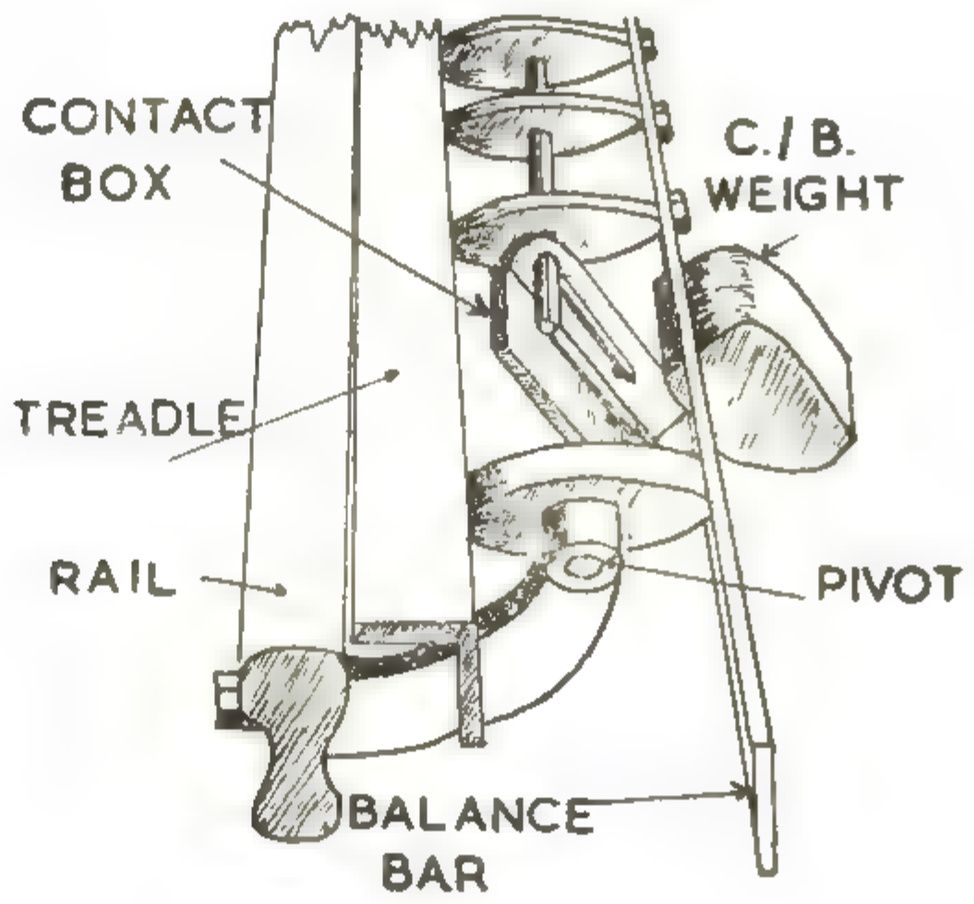


Fig. 71

carried out; this rule states, in effect, that when a train has been brought to a stop at a signal, the fireman or guard must proceed to the signal-box and warn the signalman of the presence of the train on the line. Signals fitted with plungers to the signal-box are usually distinguished by having a white enamelled diamond-shaped plate fixed to the post below the arm.

Electric mechanisms with permanent magnet motors can easily be made to give visual indication at the signal-box of their passing any given point on the track by the installation of a 1,000-ohm bobbin between the running-rails and coupled to a 1-milliammeter; the latter is deflected by current induced in the track coil by the passing of the magnet in the locomotive motor.

Coils of 1,000 ohms may be easily obtained from old

radio earpieces, each of which has two such coils in its construction, These often may be purchased for a few pence, and if the cost of a milliammeter is prohibitive, a small compass may be mounted alongside a similar coil to that used on the track. Upon current being generated in one coil, it is conveyed to the one in the signal-box, and the compass needle will be visibly deflected. Care must be taken, however, if the "compass" method is used, to

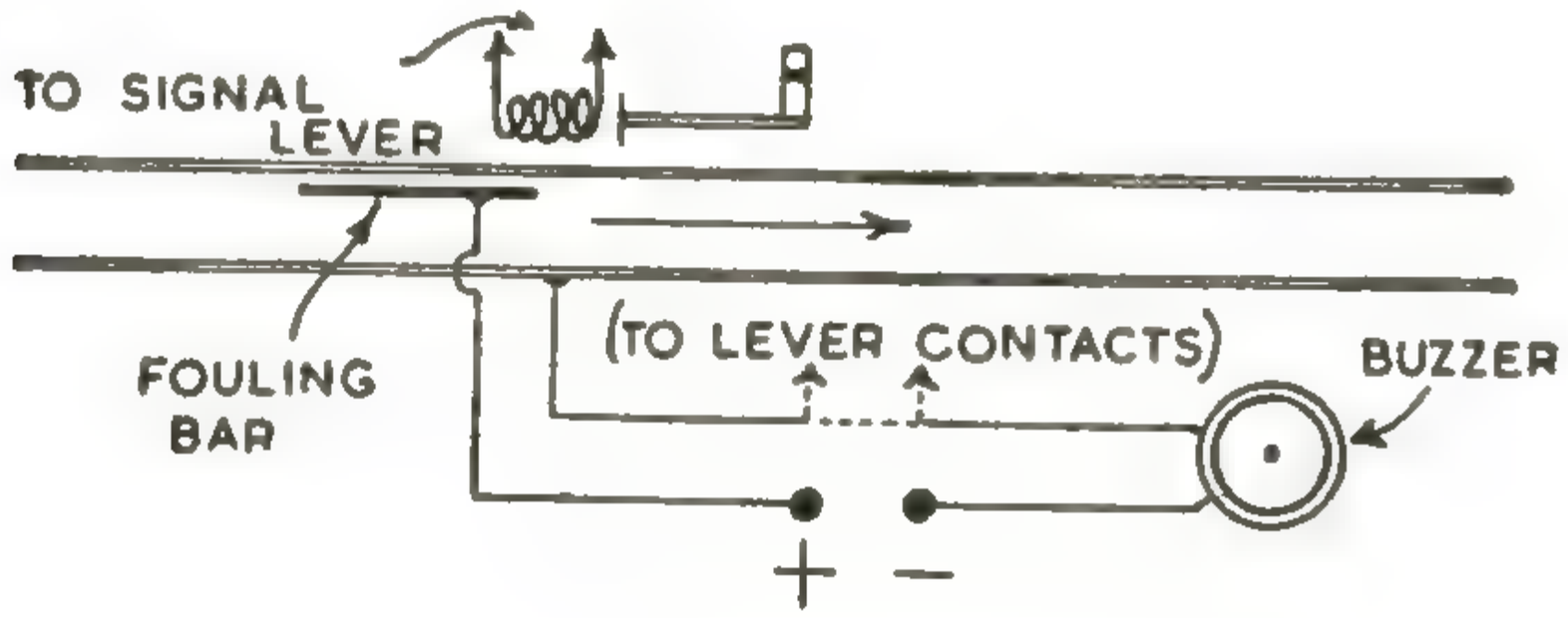


Fig. 72

ensure that the compass is mounted well away from any magnetic fields, such as are generated by transformers, relays, signal motors and other permanent magnets. The circuit used is indicated in Fig. 73, which also shows how the track bobbin is mounted in place complete with its core of laminated soft iron. The magnet of the ear-piece is discarded.

By the use of track-circuiting, the application of which to the track has already been explained, it is possible to give visual or "eye-ball" indication of the progress of a train at any part of the track without the installation of any additional batteries or contacts of any kind. The only extra constructional work which has to be done to give this added interest to train running is that entailed in the illuminated diagram or track layout, which should be placed vertically in the control desk immediately in front of the controllers.

From a study of Fig. 74 it will be seen that the indicator

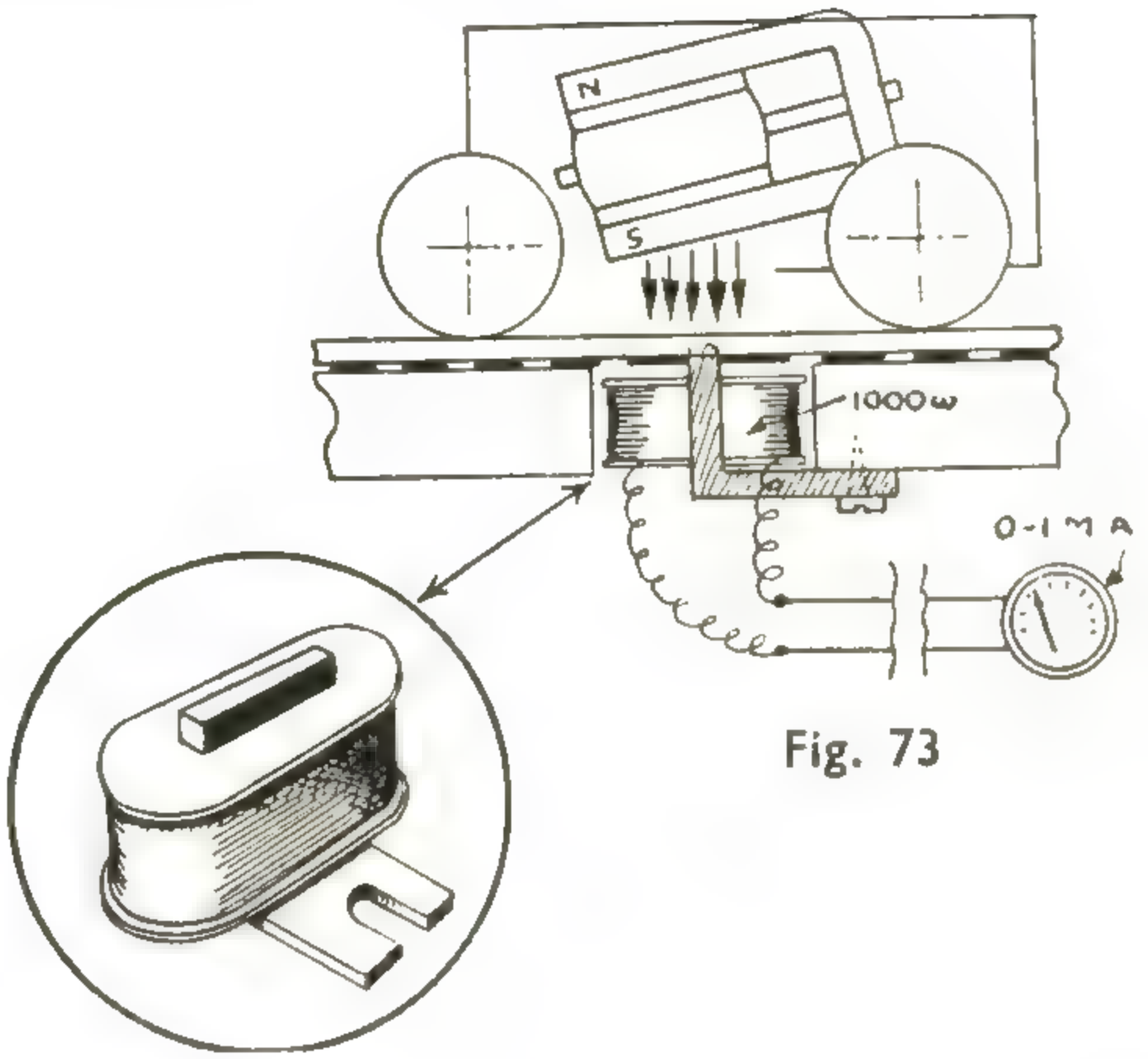


Fig. 73

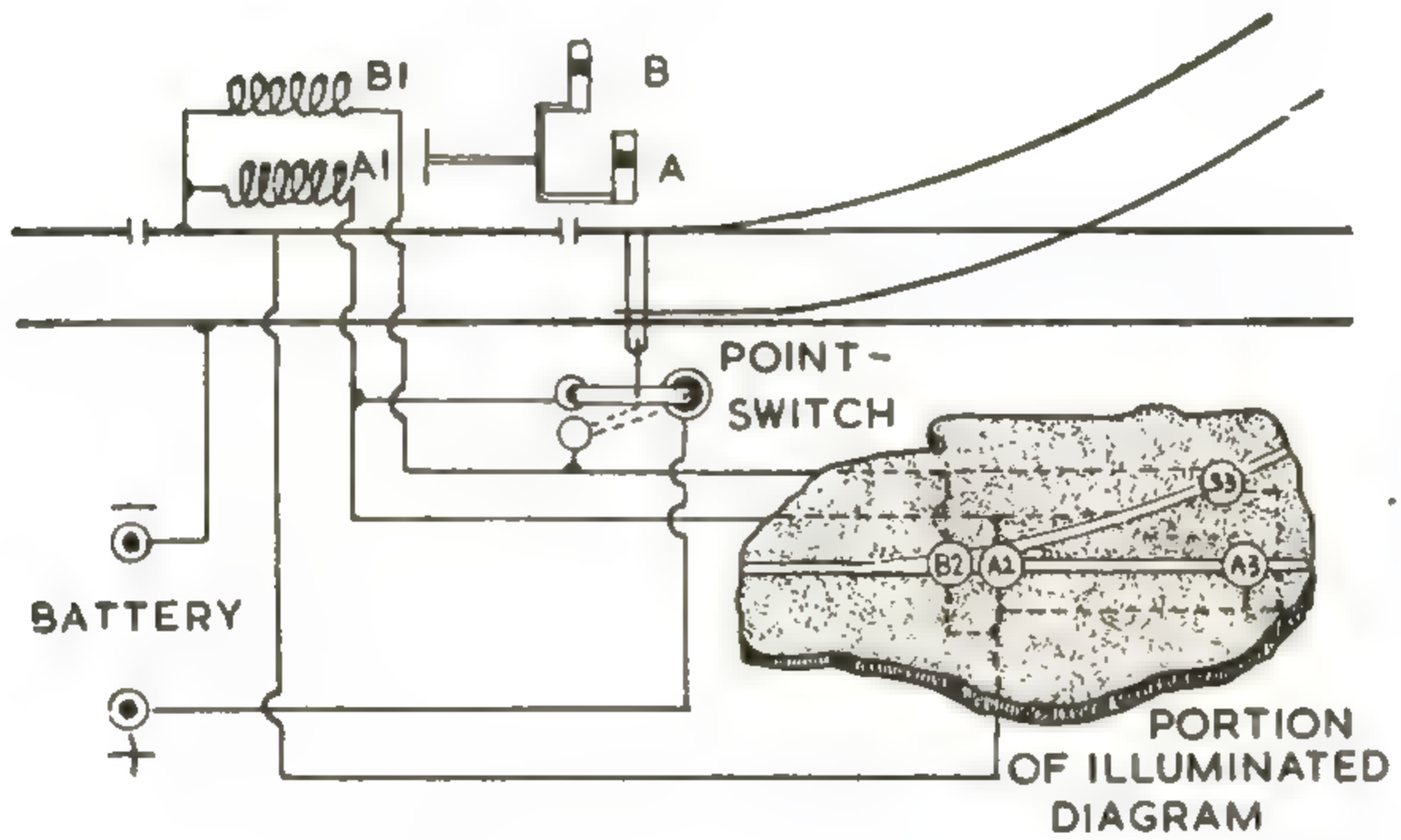


Fig. 74

lamps are wired in parallel with the bobbins of the signal motors, the action of which they " repeat " in the signal box. Thus, when the road is set for main-line, the points being as in the diagram, signal *A* is moved to the " off " position by its motor *A*1, whilst, at the same time, indicator lamps *A*2 and *A*3 are illuminated in the track diagram. When the points are set in the reverse position, signal *B* goes " off " (by motor *B*1), and lamps *B*2 and *B*3 are lighted

at the controls. When the train has cleared the section, the signal returns to " on," and the lights are extinguished.

Naturally, it is imperative that the indicator lamps are of the same voltage as that used for operating the signal motors, or of a slightly *higher* voltage if desired. It may also be said that it is futile to place the lamps in *series* with the motors, as insufficient current is passed by the lamps to operate the signal solenoids effectively.

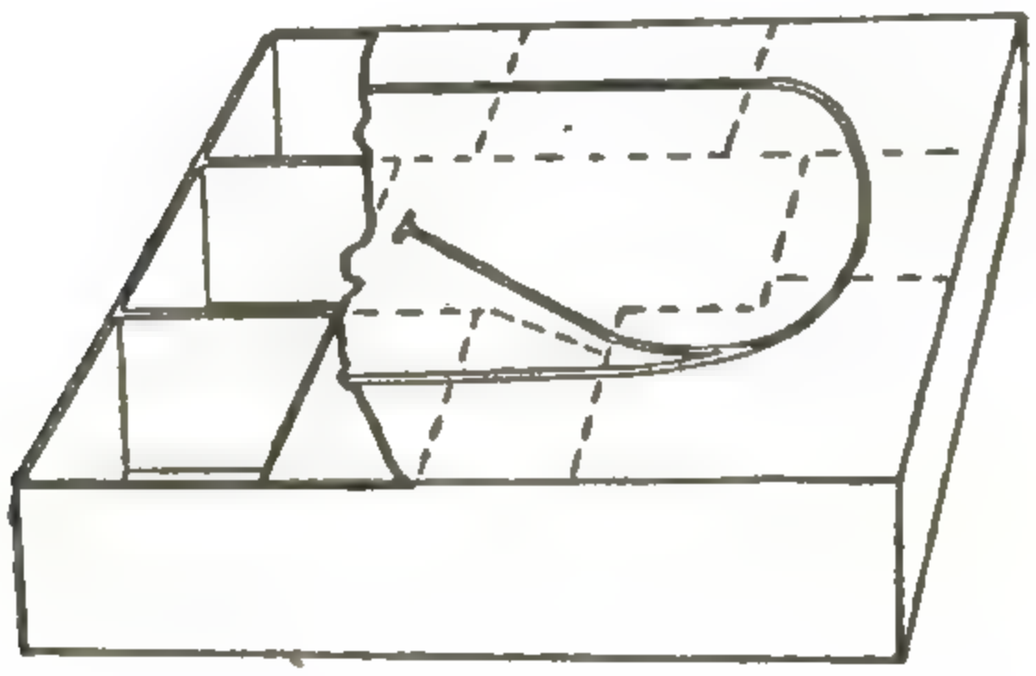


Fig. 75

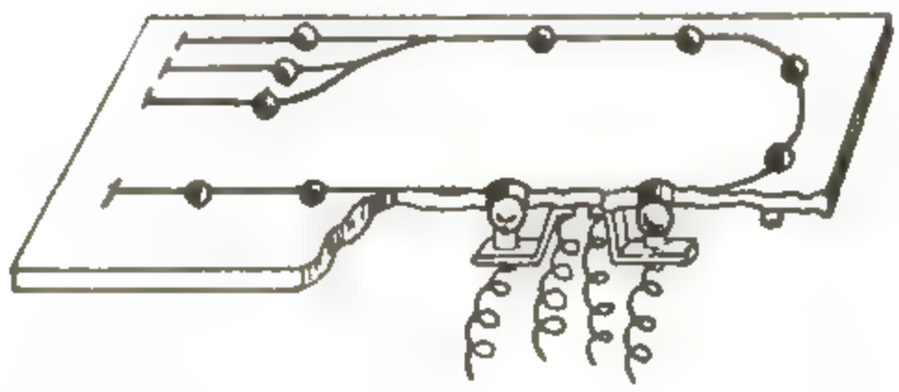
There are two types of illuminated diagrams possible in model form: the box type, and the painted board. The former consists of a wooden box, the top of which may be a sheet of glass which is painted black all over, the lines of the track being scratched thereon in diagrammatic form. Beneath the glass, and each in its own light-tight container, are fitted the indicator lamps, the light-tight divisions coinciding with the track sections indicated in the diagram, and on the layout itself. (See Fig. 75).

The second type of " eyeball " indicator consists of a sheet of three-ply upon which is drawn in diagrammatic form, the whole track layout, the track lines being marked into sections to coincide with those of the layout. In the centre of each section is mounted—below the board—a lamp, which shows through a hole drilled through the board at the mid-point of each section indicated. (See Fig. 76). When making either type of indicator, a scale of not less than 1 in. to the foot (on the layout) should be

used, so that a layout 12 ft. × 18 ft. would be represented by an indicator 1 ft. × 1 ft. 6 in., which will be found a convenient size to fit with lamps and wire up. Smaller indicators are difficult to read, and larger sizes are apt to be cumbersome.

There is no reason why this cheap and simply-installed system should not be elaborated to suit local layout conditions, special indicator lamps—coloured to differentiate between up and down roads—being introduced to show the occupation of sidings, bay roads, and carriage

Fig. 76A



sidings. It will be apparent to the reader that the principle of the indicator can be used, if desired, without operating electric signals. In this case, a wire is taken direct from the appropriate section lamp to the insulated track-section, instead of running through the signal solenoid, as shown in Fig. 74. Indicators of either type are equally effective on clockwork or steam-operated layouts, and, in these cases, can offer the intensely interesting operational feature of following the progress of a train—even when it is lost to view from the control panel—by the successive illumination of the various sections of the diagram.

A couple of small dry-cells, or three Leclanché batteries will provide all the necessary current for illuminating the diagram if signals have not also to be electrically worked ; but it is a good plan to ensure the saving of the batteries by fitting a double-pole " main " switch, by which the batteries can be entirely disconnected from both the indicator and the layout. Alternatively, of course, a

200-50/2-, 4- or 6-V transformer can be used, running " from the mains."

Now as to a few final installation and upkeep hints to bear in mind when using power signalling, for like most jobs, there is a " best way " of tackling the work. In all cases, when a layout is being equipped for electric signalling rail joints and fishplates must be carefully soldered to reduce their resistance and to ensure reliability of electrical contact. All feeder wires should be soldered to the rails or ramps they feed, and should be protected from touching

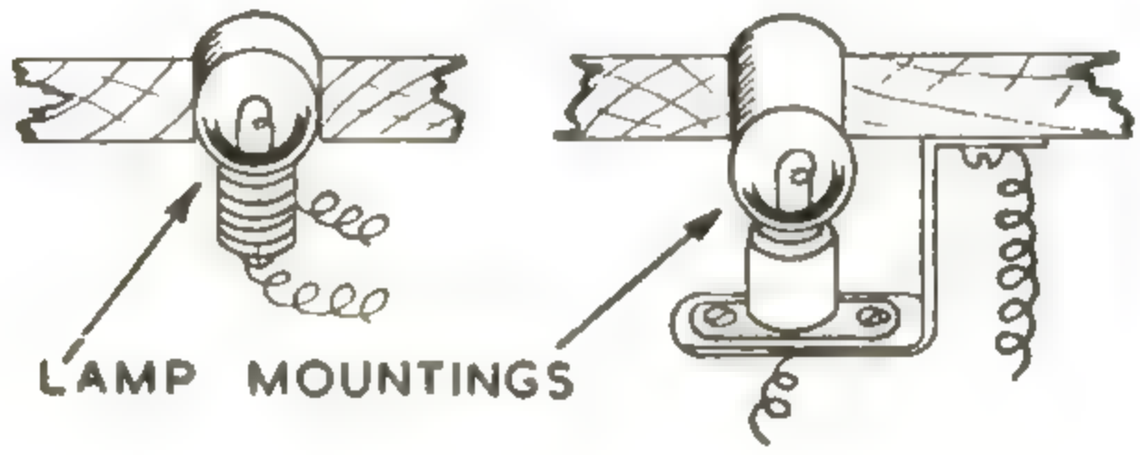


Fig. 76B

other rails and wires by slipping over them lengths of " Systoflex " or other insulation tubing—valve-rubber is quite satisfactory if " Systoflex " cannot be obtained.

The wheels of locomotives and vehicles (particularly the last vehicle of each train) *must* be kept free from grease and grime, especially when using the alloy wheel/steel rail combination, which is singularly prone to collect dirt by reason of an electrolytic action taking place between the zinc in the alloy wheels and the steel of the track. For cleaning both wheels and track nothing will be found more effective than carbon tetrachloride (" Thawpit ") or ethylene dichloride. Paraffin merely spreads the grease without removing it.

It is best not to attempt to complicate any circuit until a thorough working knowledge of the underlying principles upon which it operates has been gained by usage; for mention has already been made of the differences of individual opinion existing on the vexed subject of train signalling—in model form, and it can well be

reiterated that almost all of the foregoing circuits are capable of modification to suit the layout, ideas, ideals—and pocket of the reader,

Finally, it may be said that tidy sub-baseboard wiring is really essential to trouble-free signal operation, and, if possible, colour-coded wires (which are commercially obtainable from the makers of model railway power-packs), should be used, because it will be found much easier to trace faults, should they occur after the electric signalling system has been brought to completion. Neatness of wiring is, however, in the writer's opinion the most important matter to remember. " More haste, less speed " should be the reader's motto.

CHAPTER SIX

THE immense possibilities of electronic control devices in modern industry and the public services have been quickly grasped by engineers, who have lost no time in pressing them into work at many jobs which have previously been considered only possible by human means, with a brain behind to direct and order operations.

It is, however, now well known that suitable apparatus and circuits, together with the use of photo-electric cells, electronic valves and valve amplifiers, have rendered it possible to dispense with the human element in many thousands of industrial and engineering processes, which are made entirely automatic and 100 per cent. efficient thereby.

Electronic engineering can be successfully used to assist in the operation of even the humblest model railway, and if a little care and forethought are used, there is absolutely no reason why the average model railway enthusiast should not delve into realms hitherto not considered as part of the hobby and build for himself the simple apparatus required to operate his line electronically—as regards signal, and many other point controls.

One of the features of this system is that no additions of any kind are needed, either to the track or to the rolling-stock, to permit the latter to operate its own signals and points. There are no ramps, track-circuits, trips or "gadgets" on the track, and no magnets or trip-levers on the electric mechanisms of the locomotives. Everything

becomes subject to photo-electric cells, simply-made valve amplifiers and relays, all of which combine to produce the desired automatic operation of the model layout, being placed at strategic points for that purpose.

The key device to the whole situation is the photo-electric cell, of which there are broadly two distinct types: the true cell, which consists of two special electrodes, sealed into an exhausted chamber (after the manner of a radio valve), and the selenium unit, which is generally termed a "cell." These two types are shown in Figs. 77 and 78.

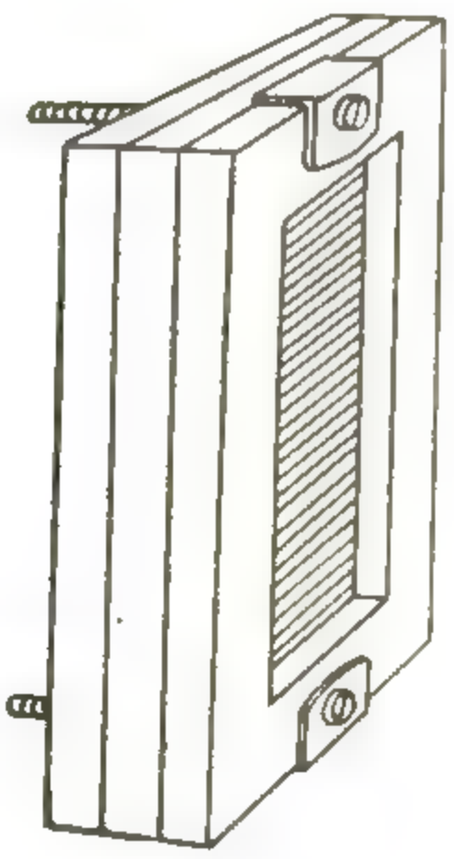


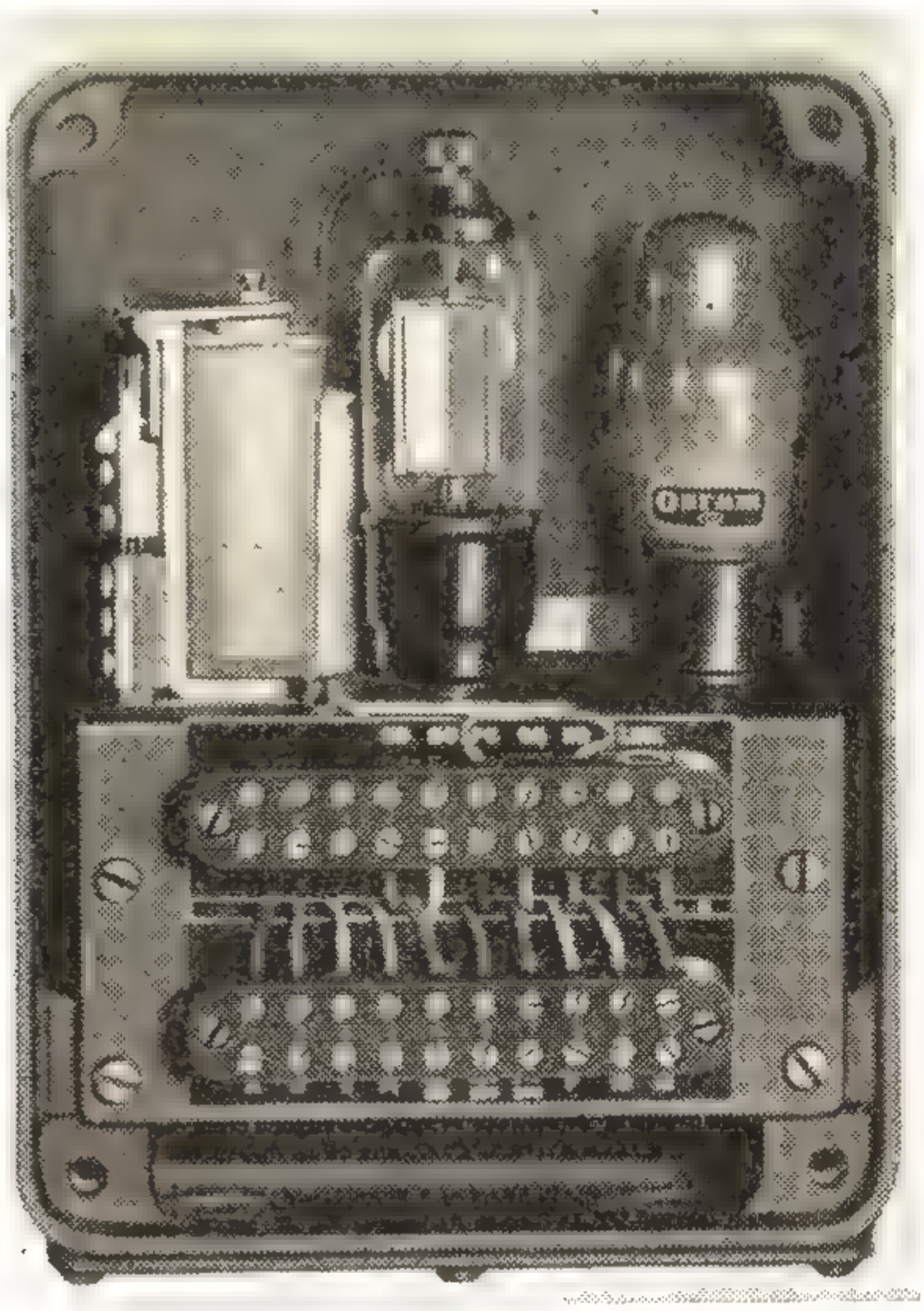
Fig. 77

The true photo-electric cell is a device which possesses the property of converting light rays into electricity, and in doing this it functions in much the same way as a radio valve. But, whereas in the latter case, the cathode has to be heated to emit electrons—thus producing a flow of electricity—the photo-cell produces the same effect by allowing a ray of light to fall upon the cathode, which is coated with a light-sensitive metal, such as caesium or potassium.

The selenium "cell" is not, in fact, a generator of electrical energy, but operates by reason of the fact that its electrical resistance drops very considerably on exposure to light; and the uses to which this varying resistance can be put are many; for, by suitable arrangements and circuits, other circuits can be controlled either by light or the invisible infra-red rays.

Apart from the fact that selenium is not emissive, it possesses another disadvantage which does not permit its use for "talkie" or television work; and that is, its relative slowness in reacting to light. The resistance of the cell decreases, and the current passed rises very rapidly

when light is first allowed to fall on it; then continues a slow rise, followed by the maximum current (minimum resistance). When light is cut off from the cell, this time-lag is even more pronounced. (Fig. 79).



(Courtesy of G.E.C.)

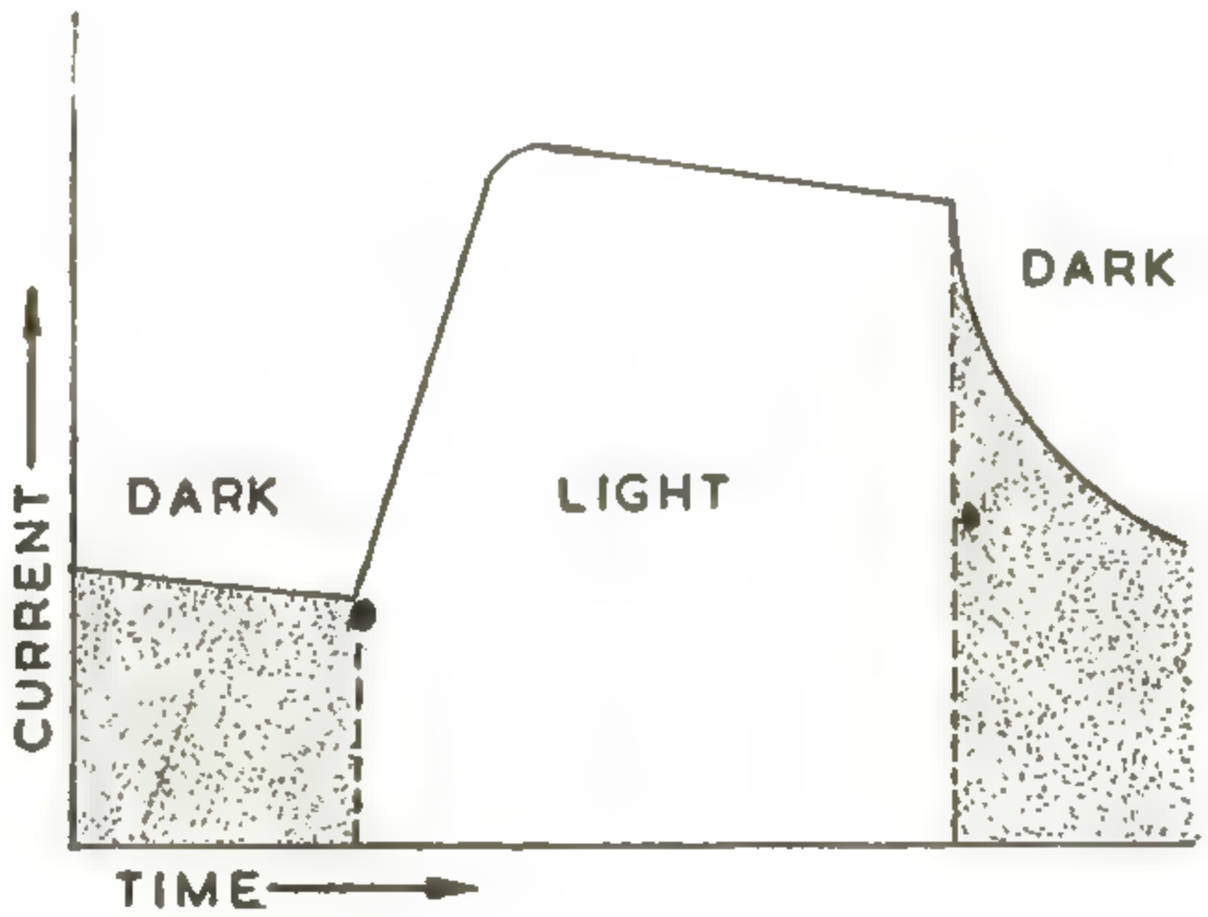
Fig. 78

Although these drawbacks to the use of selenium cells are of great import when they are used for scientific work, they are fortunately of little consequence so far as adaptation to model railway work is concerned; for, in a number of instances, the selenium cell is quite equal in many ways to the much more expensive photo-cell, and lends itself to home construction at very small outlay.

The cost of making selenium cells is only a matter of a few pence each, and the reader will do well to make one with which light control experiments can be carried out on the layout. There are several types of selenium cells

at present in use, and there are many ways of constructing them by methods well within the skill of the average model railway engineer. All the materials which are required in the making of a cell are (*a*) a small piece of good quality roofing slate, about 2 in. × 1 in., (*b*) two pieces of ebonite, each about 3 in. × 2 in., and (*c*) a "BBBB" pencil or a block of blacklead.

Fig. 79



From the scrap of slate cut, with a hacksaw, a rectangular piece 2 in. long by 1 in. wide, and after filing up the edges square and clean rub the blacklead all over the surface of one side, to form a good conducting surface. Next, with a triangular file, cut grooves across the blackleaded surface, "zig-zag" fashion, so that the filed groove effectively starts at one end of the slate and zig-zags continuously down to the other end. (Fig. 80).

Next, the two ends of the slate must be heavily blackleaded, so that, eventually, connections can be taken from each end. A check may now be made to see if the graphite is continuous from one end to the other by including the cell in series with a 12- or 6-V battery and milliammeter (Fig. 81).

Now comes the most important operation—that of coating the surface of the slate with selenium, and it should,

therefore, be placed on a sheet of asbestos on top of an inverted domestic electric iron. (Fig 82). It should be heated to the melting-point of selenium (217 deg. Cent.), and when this temperature is reached, the metal will melt and run over the grooved surface of the slate. The colour of the selenium will give a good visual indication of its tem-

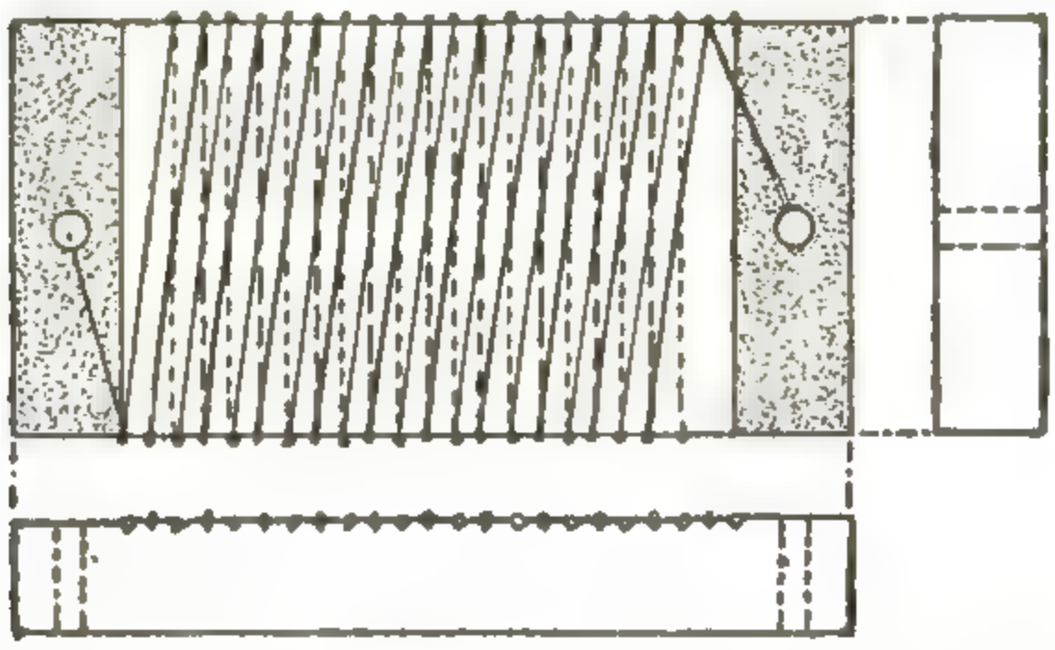


Fig. 80

perature if a thermometer is not available, turning grey if the temperature is too low, and showing little globules in its surface if the heat is too fierce. Moreover, at a too-high temperature the selenium will be found difficult to spread; but no such trouble occurs at its correct melting-point temperature.

After the selenium has melted and run over the surface of the plate, the temperature should be maintained for

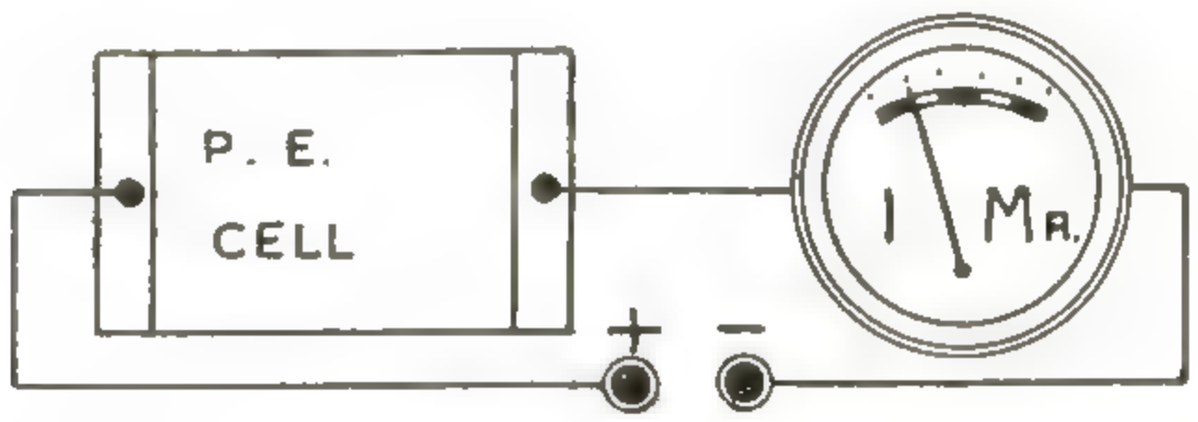


Fig. 81

about 40 minutes, during which time all surplus should be scraped off level with a piece of post-card until an even, thin layer is left in the grooves and over the whole surface of the cell. After this, the heat should be gradually reduced every half hour for two hours, which is easily effected if a thermostatically-controlled iron is used for the job.

All that remains now is to mount the cell between the two pieces of sheet ebonite, one of which has its centre cut out to expose the sensitive cell. A No. 27 hole (clearance for 4 B.A.) should be drilled through both pieces of ebonite and the slate, so that all three can be bolted together. Before bolting, however, a thin piece of sheet copper should be placed over the heavily-blackleaded ends of the slate, and bent over to make good contact with the 4-B.A. terminal bolts. (Fig. 83).

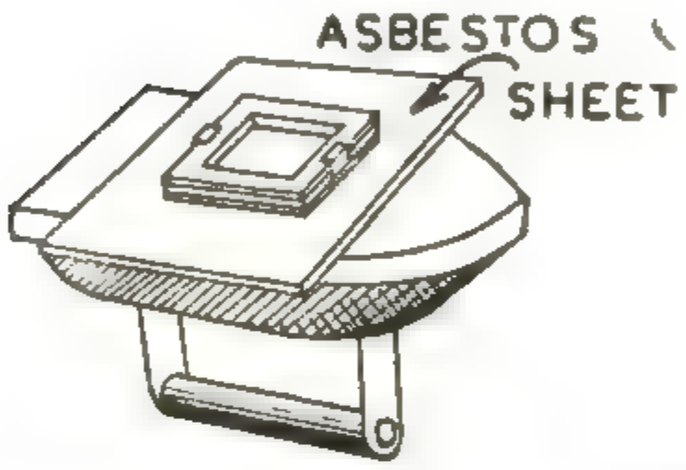


Fig. 82

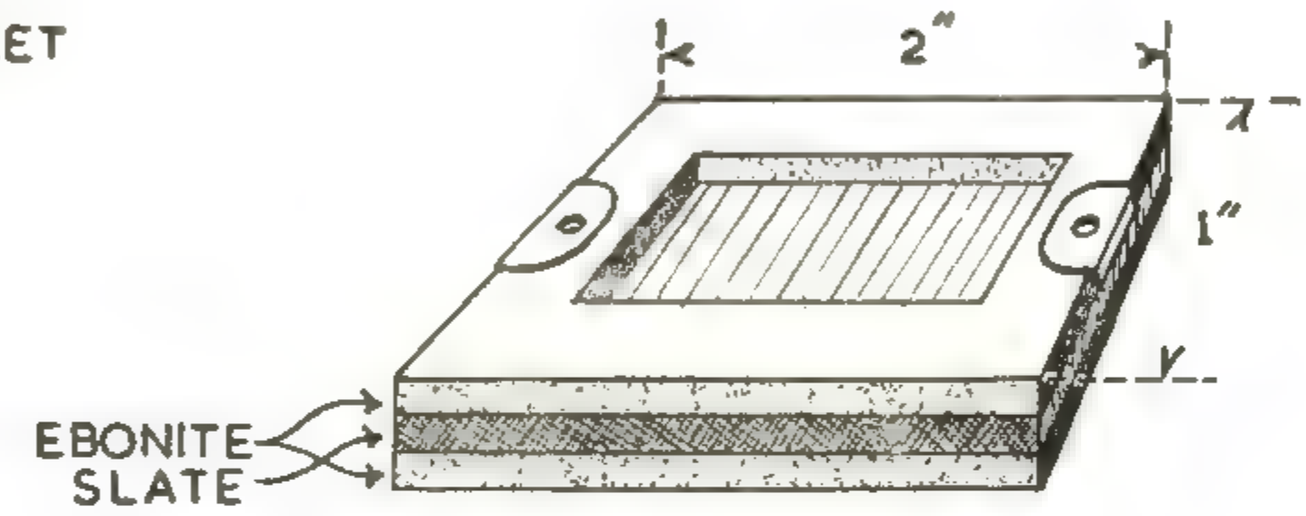


Fig. 83

There is another method of cell construction which may appeal to some readers by reason of its greater simplicity, and this also has for its foundation a slip of slate 2 in. × 1 in. In this case, however, nicks are made with the three-cornered file at 1/32 in. intervals all down each side. Into these grooves is wound No. 28 s.w.g. bright copper wire, which is wound into every other groove first, and then another piece of wire wound in between the first piece, as shown in Fig. 84. The two wires are wound in this manner, and one end of each taken out to terminal bolts as in the previous cell.

The method of application of the selenium is exactly the same as already described, but the cooling-off (annealing) process after application is *very important*, and has a direct bearing upon the sensitivity of the completed cells. It is a good plan to re-heat the cell to almost its melting-point, after it has first slowly cooled, and to repeat this

process two or three times before allowing it to cool finally.

Home-made selenium cells of the types described will give very good results on " light-dark " circuits, and though not quite up to commercial standards, are very cheap to make and will, under illumination, pass a steady current of 1 mA, which is ample to operate the relay about to be described.

The difference between the " dark " and " light " resistance of a selenium cell has already been mentioned, but since the term may be strange to some readers an explanation may not, perhaps, be out of place. The " dark " resistance of a cell is the resistance it offers to the steady passage of electricity when the cell is in the dark—i.e., without light actually falling on it,

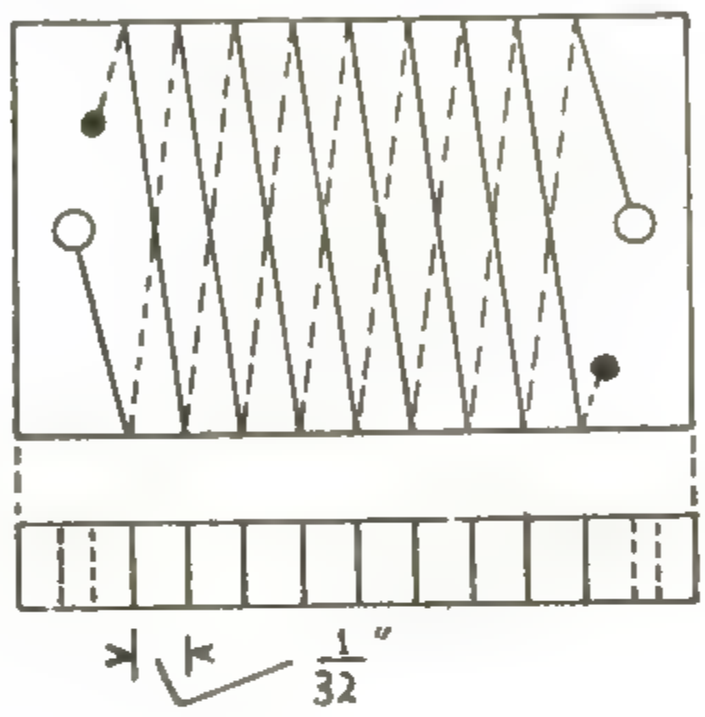


Fig. 84

and this resistance can generally be expressed in megohms (millions of ohms). It will be seen, therefore, that as it offers such a high resistance to current flow, hardly any current will pass through a cell from a 60 V. supply source, the current being virtually cut off.

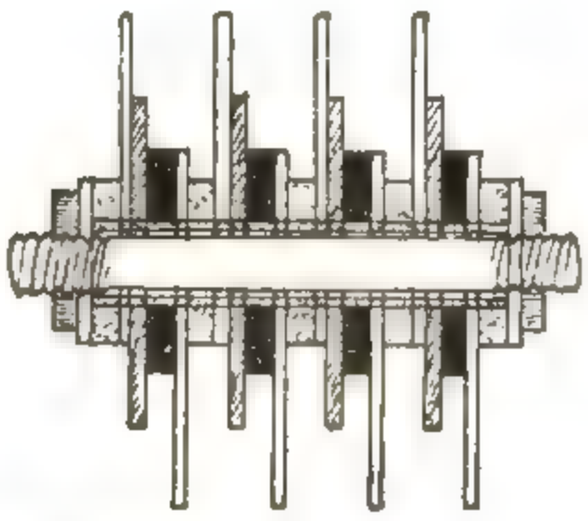
The " light " resistance of a cell is very much lower, being usually in the neighbourhood of 50,000 ohms (in a well-made cell); thus, quite a goodly amount of current will be passed through the cell under illuminated conditions, and can be fed through an amplifier and relayed to do useful signalling or point-motor operation.

It will be seen, therefore, that the goodness of a selenium cell is measured by the ratio between its " dark " and " light " resistances, the resistance of the cell being in inverse proportion to the illumination and very nearly proportional to the square root of the intensity of the light. It is relatively less sensitive to brilliant lights than it is to

moderate illumination, which is a feature, considering the purposes to which it will be put by the model railwayman. No other type of light-cell is comparable with selenium in this particular aspect.

For those readers who do not wish to make their own selenium cells, and yet cannot justify the expense of a commercially-made photo-electric cell, there remains a ready source of material with which another type of light-sensitive cell, known as the " rectifier " or " photronic " self-generating cell can be constructed. These cells are different in construction and principle from the emissive cell already noted, and comprise a disc of metal coated with a partial conductor; such combinations as selenium and iron, and copper and cuprous oxide are used.

The copper oxide type will possibly have been recognised by the reader as the same combination as that used in the Westinghouse rectifier, whilst the selenium-iron type is to be seen in the selenium rectifier units now in use for converting a.c. to d.c. for model railway power supplies and other purposes.



SECTION OF SELENIUM RECTIFIER

Fig. 85

The basic principle of these cells, when used as light-sensitive devices, is common to both types, The upper face of the cell is coated with cuprous oxide, and is exposed to illumination, and the lower—bright copper—side forms one terminal of the cell, whilst the oxide layer forms the other.

When the oxide (or selenium coating on iron) is illuminated, there is a steady flow of electricity from the oxide to the copper (or from the selenium to the iron) and it can be measured on a micro-ammeter or fed into a single-valve amplifier and thus made to work a relay for signal operation.

By purchasing a selenium or copper-oxide rectifier unit

at a radio store or government surplus depot, as many photo-cells can be made from it as there are cooling fins on the rectifier unit. (See Fig. 85). By preference, how-

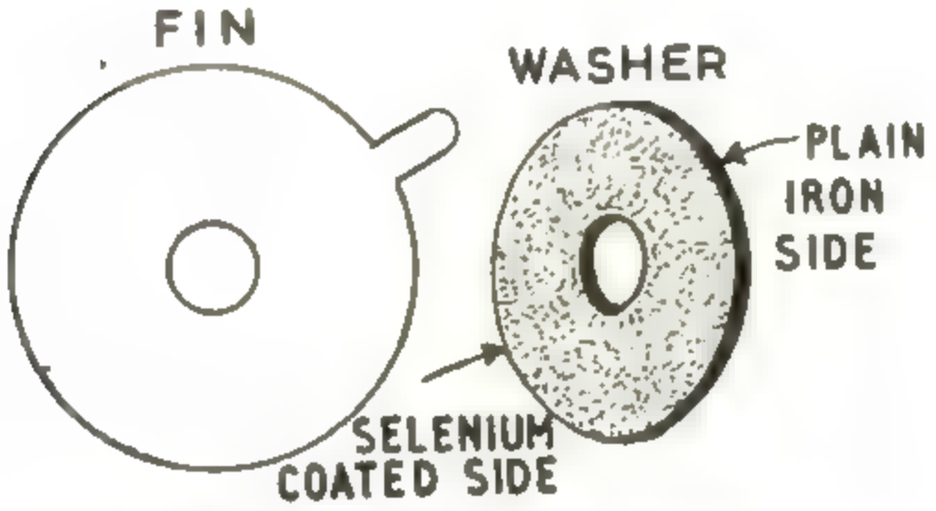


Fig. 86

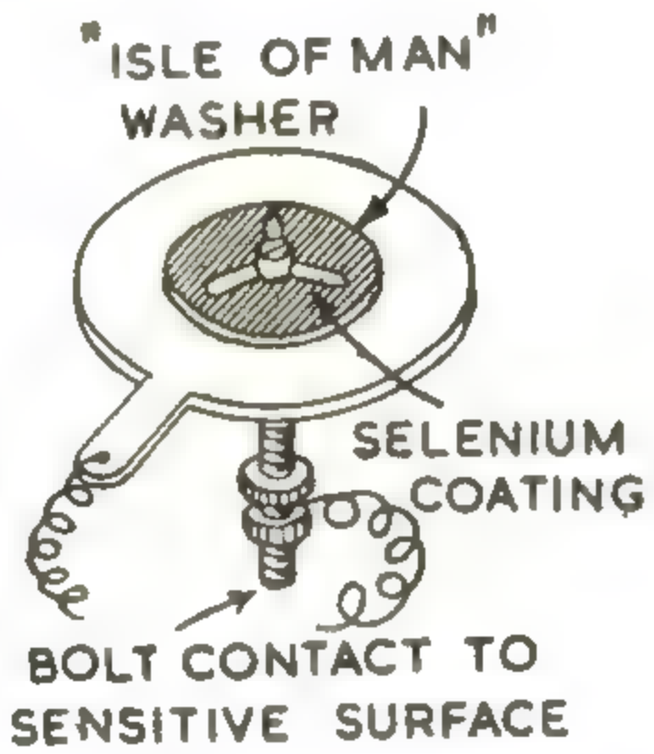


Fig. 87

ever, a rectifier unit with fairly large cells should be chosen, and one capable of handling 12 V at 1 A is suggested.

The unit must be very carefully taken to pieces by unscrewing the nuts at each end of the central rod, after which the end washers can be removed, together with the vulcanite end-cheeks. The stack of rectifier cells must now be broken apart, and, (in the selenium type) there will be noted alternate washers of iron and selenium-coated iron, the latter being distinguishable by a thin silvery-grey layer on one side of the washer. (Fig. 86).

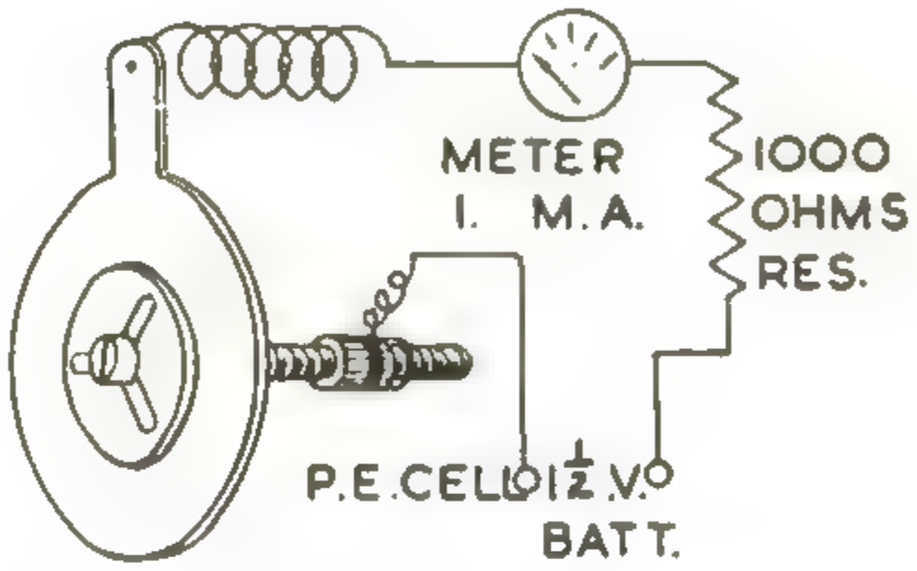
If possible, try to keep one washer (coated) in its original position with its iron back touching one of the cooling fins, because when it is used as a light-cell, the tag of the cooling-fin can be used as one terminal of the photo-cell. (Fig. 87).

The re-assembly of the separated washers of various kinds into a light-cell are depicted in Figs. 86 & 87, where it will be seen that a 2-B.A. bolt is passed through the centre hole, to form a terminal, contact with the selenium-faced washer being effected by means of an " Isle-of-Man " washer placed under the bolt head. An insulated washer

must be placed at the back of the cell, so that the central bolt and nut do not touch the plain iron back of the washer.

This new assembly now constitutes a light-sentitive cell, and if it is exposed to sunlight or a bright light, it will

Fig. 88



produce a reading on a meter if wired as shown in Fig. 88; but before it can be made to do any useful model railway work, this small output must be amplified and made to work a relay, and it is, therefore, imperative that at this iuncture the question of amplification and relays is discussed.

CHAPTER SEVEN

OWING to the efficiency of present-day radio valves and their cheapness—especially when purchased on the " war surplus " market—the question of amplification presents no great difficulty; and the small output of a photo-cell of any type can be built up to almost any required level.

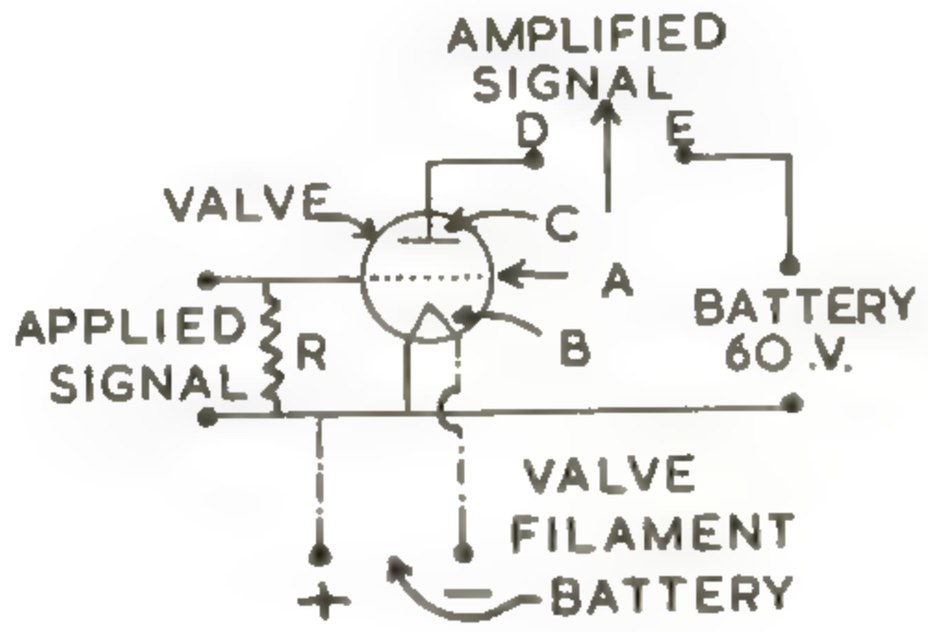
The basic action of the radio or thermionic valve is now too well known to need very much explanation; but for those readers not conversant with its method of functioning, it may be briefly said that any electrical signal or variation applied to its grid (*A* in Fig. 89) and cathode or filament (*B*), will cause an exactly similar but greatly magnified reproduction of that signal in the anode (*C*) circuit• the magnified current appearing at the terminals *D*-*E*, the power being derived from the local battery which may be one of 60 V.

In Fig. 89 is shown a simple circuit for a one valve amplifier in which the anode of the photo-cell is connected to the grid of the amplifying valve, the cathode of the photo-cell being connected to another 60-V battery. The current from the photo-cell, in flowing through the resistance (*R*), produces a difference in voltage at either end of it; and this " potential difference "—as it is called—is passed on to the grid of the valve.

This change in grid current will give rise to a greatly magnified change in the anode current of the valve, so therefore the minute change in the output from the photo-

cell will produce a change of several milliamps in the output from the valve; and this latter current may be measured by placing a 0-10 milliammeter across the terminals *D-E* (Fig. 89), taking care that the positive terminal of the meter is connected to *E*, and the negative to *D*, respectively.

Fig. 89



In Fig. 90 is shown a simple circuit which is designed to operate a meter or relay when light is cut off from a photo-cell, and it will be seen that the diagram, Fig. 89, fits into the circuit with some few additions. It should be noted that the resistance (*R*) should be from one to two megohms, resistances of such values being readily obtainable from radio stores as " grid-leak " resistors.

It will be seen that the grid of the valve is permanently biased negatively by the grid battery *via* the resistance *R*, and that a variable resistance (*R*2) of about 30 ohms is inserted in the filament lighting circuit, so that the steady output of the valve (when not receiving any signal) can be adjusted to suit the relay used. It is an advantage to have this control as fine as possible.

To enable a light-cell to operate a relay when light is directed on it (i.e., the reverse action to that given by the circuit of Fig. 90) the photo-cell connections are reversed, the cathode instead of the anode being connected to the valve grid. (Fig. 91).

To allow of a common high-tension battery being used

for both the photo-cell and the valve supply, the circuit shown in Fig. 92 is used, which considerably simplifies and cheapens the amplifier.

Now as to the items necessary to build the valve amplifier the alternative circuits for which are shown in Figs. 90, 91 and 92; the last circuit being pictorially illustrated in Fig. 93.

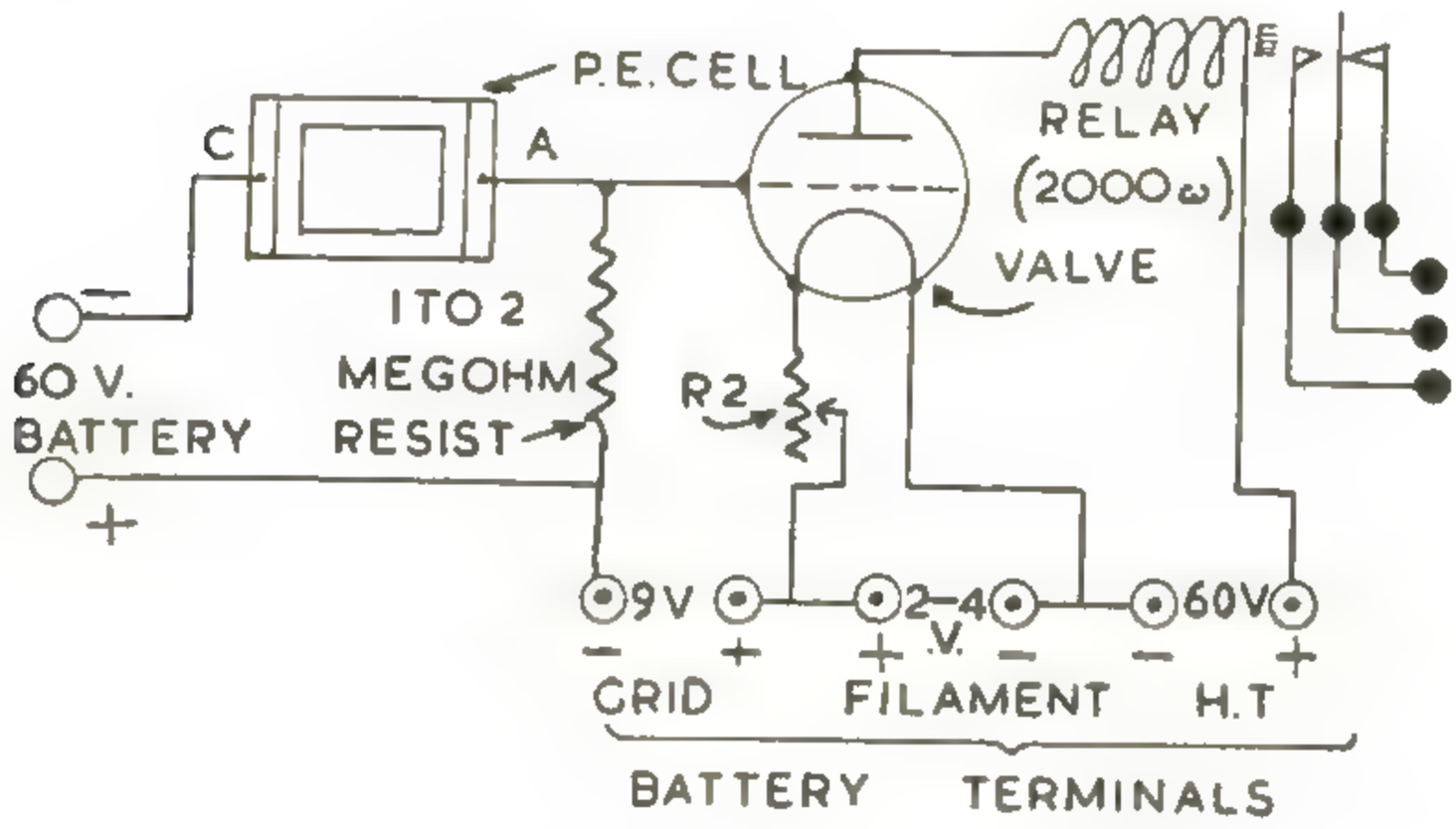


Fig. 90

One four-socket valve-holder will be required, together with one 30-ohm, base-board-mounting variable resistance; one each, one and two megohm ½- or 1 W. grid leak resistors, and ten terminals. The total cost should not exceed five or six shillings.

As to the correct valve to use, this depends upon the source of power used to light its filament. If a 2-V. accumulator (or one section of the 6- or 12-V traction accumulator) is used, then a power valve of the 2-V. series is required. This range includes Mullard PM2, Mazda P215, Marconi DEP215, and Osram DEP215, all of which are 4-pin triode valves capable of handling the current from the photo-cell. It is not necessary that a brand new valve is purchased, as a second-hand one will serve provided its emission (i.e., its capability of passing current) is not low; the minimum figure for this is 5 mA. When new, battery power valves will usually pass as much as 8 mA.

AND POINT OPERATION

By placing the photo-cell in circuit with an amplifier of this type, it becomes possible to control any local signalling or other circuit by means of a relay, the local power to operate which is derived from a 60-V radio " high tension " battery which is connected to the appropriate terminals of the amplifier.

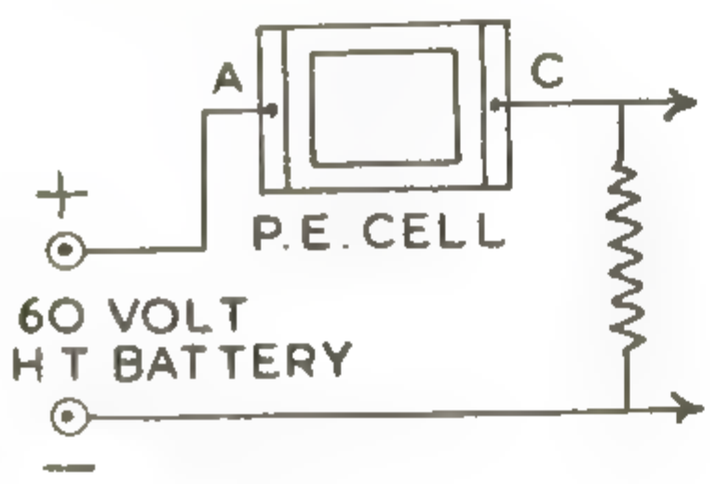


Fig. 91

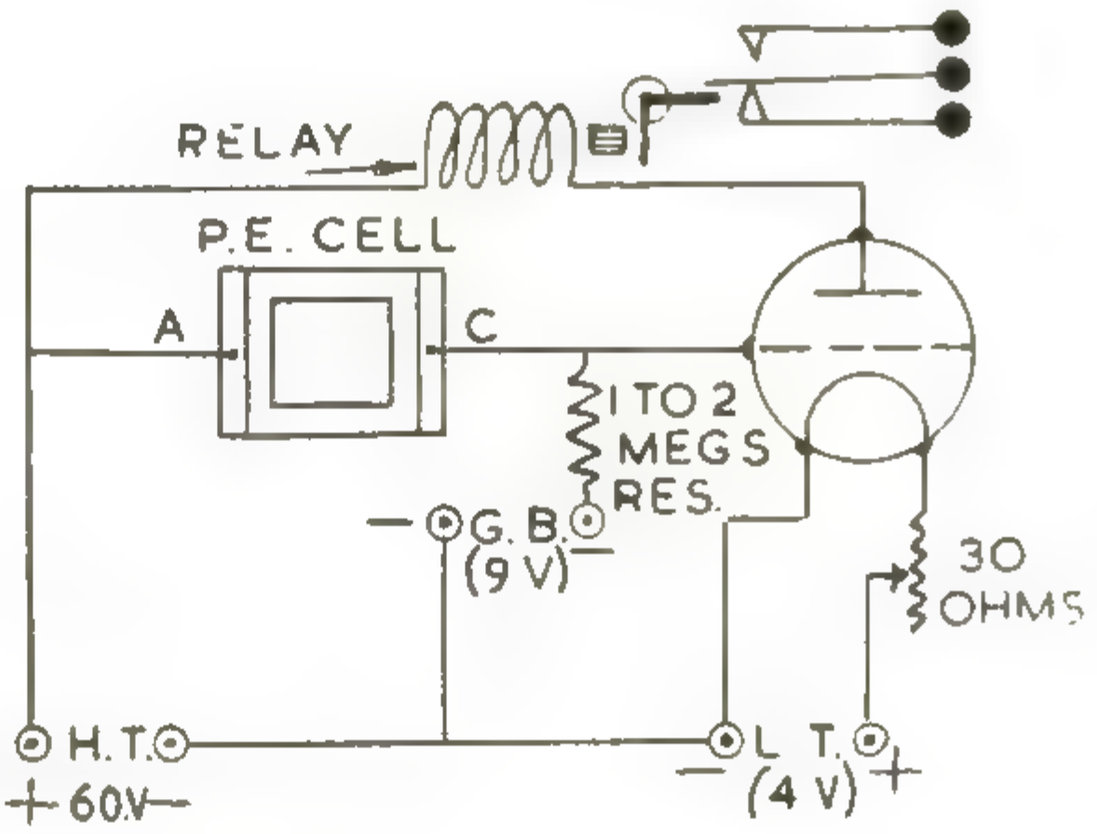


Fig. 92

The construction of the amplifier should not offer any difficulties if the components are mounted upon a piece of soft wood about 6 in. × 4 in., the terminal strips being made from ebonite or fibre to the dimensions shown in Fig. 94, and mounted on the baseboard as shown. The whole job is simple in the extreme. The grid wire should be kept as short as possible, and well away from all other wires on the unit.

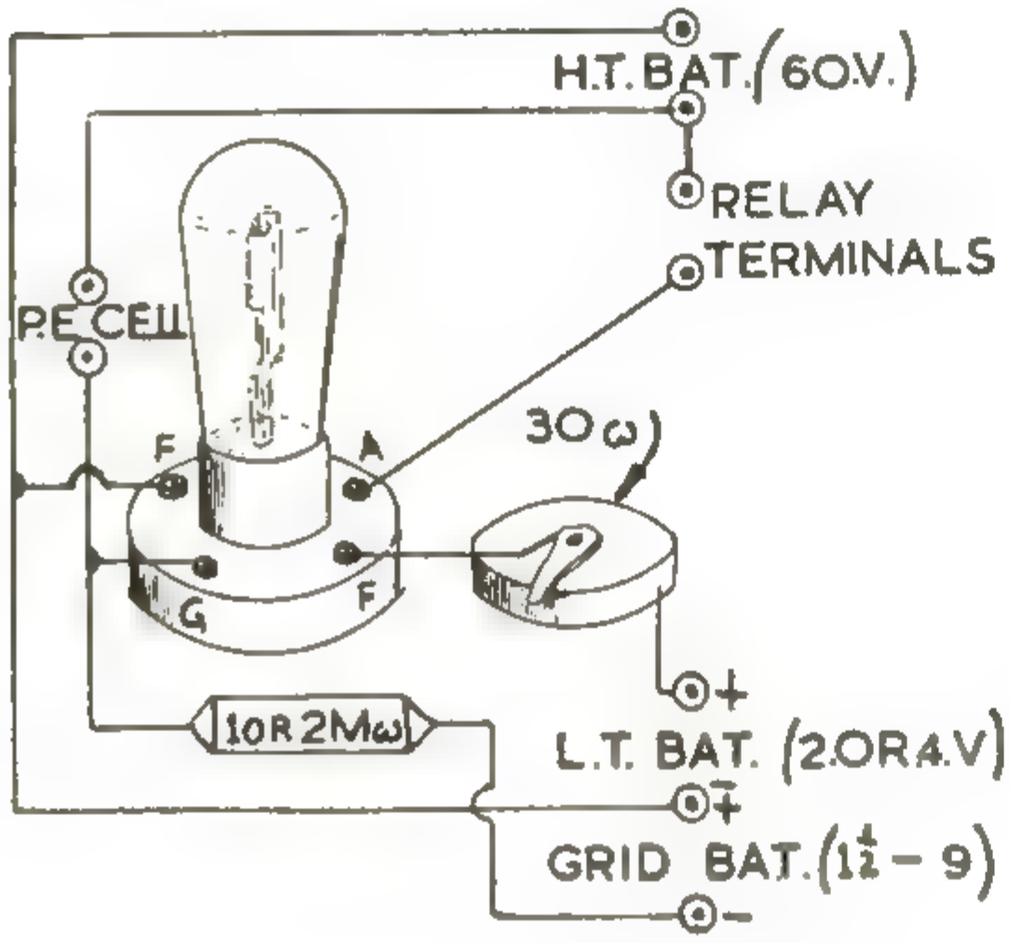


Fig. 93

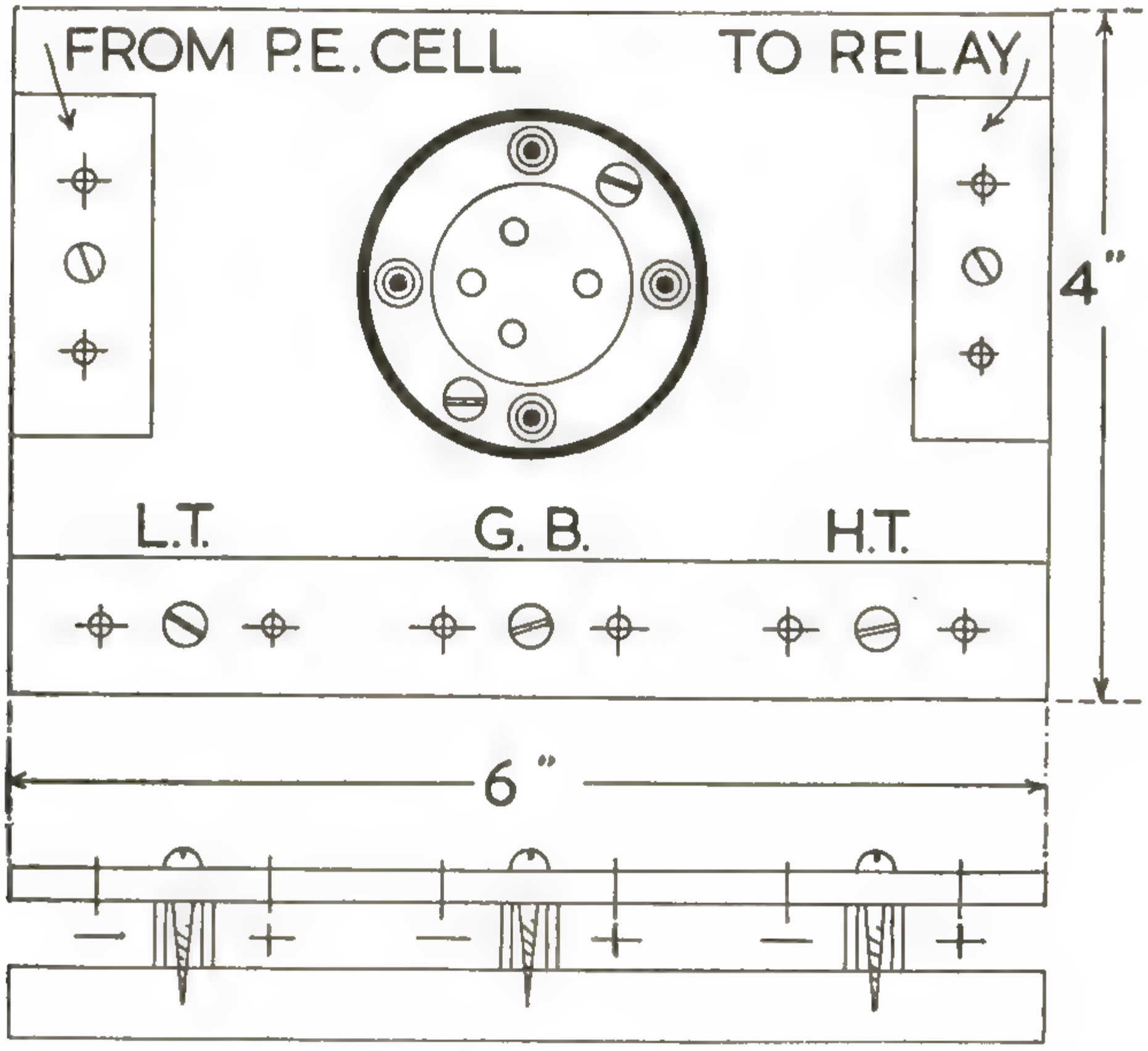


Fig. 94

Coming now to the question of the electro-mechanical relay by which the much stronger current is switched on and off to operate the signal or point solenoid, this, fortunately presents no great difficulty, because perfectly suitable relays are both easily and cheaply obtainable as Post Office and war surplus at most of the appropriate advertisers in "*The Model Engineer.*"

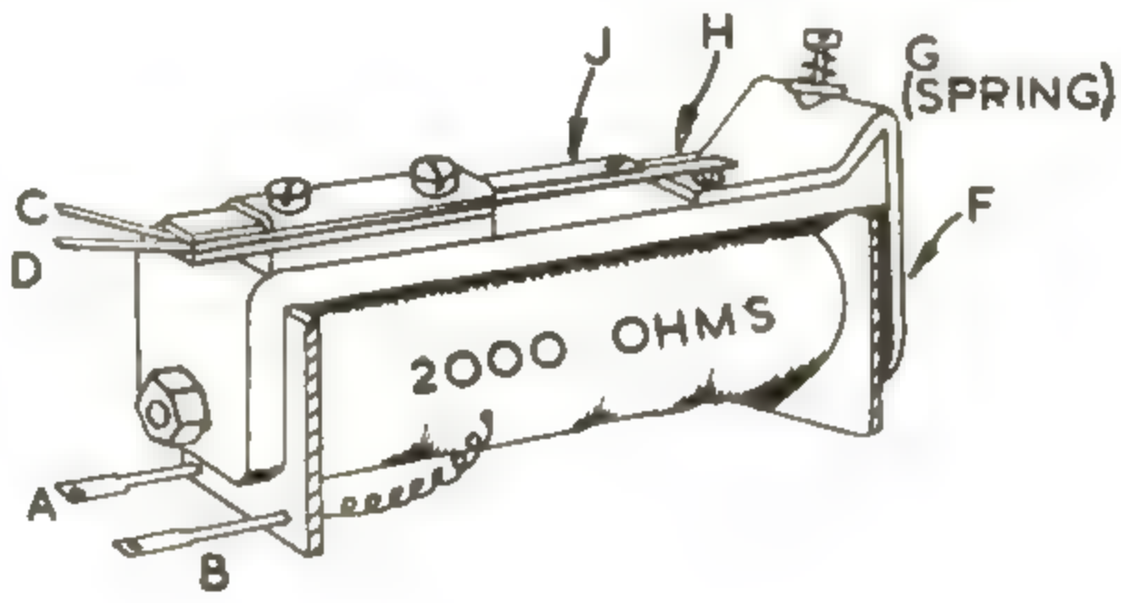
One should be chosen which has a winding resistance of about 2,000 ohms, and is sensitive enough to operate on a current of not more than two or three milliamperes. The cost of such an item is usually in the neighbourhood of five shillings, and its general appearance is depicted in Fig. 95.

For those readers who are not conversant with the method

by which a relay works, it may be said that it consists of an electro-magnet which becomes sufficiently magnetised to pull towards it an armature (*F*, Fig. 95) which is pivoted on a knife-edge and held in place by the screw *G*. When the armature is attracted towards the core, its other end (which is bent at a right-angle) raises the relay contact *H* into contact with *J*, thereby allowing a flow of current between the relay terminals *C* and *D*. Thus, when the small output from the valve amplifier is fed into the relay terminals *A* and *B*, the relay operates and switches the greater local current by means of contacts *H* and *J*.

We are now in a position to wire the amplifier, relay and local power-supply into circuit to do a real job of work on the railway layout, and Fig. 96 shows the circuit necessary to bring about the desired effect of moving a signal to the "off" position when a ray of light falling on the photo-cell is broken by the passage of a passing train casting its shadow.

Fig. 95



It may be that many readers will be "scared" of tackling the building of the P.E. cell and its amplifier unit, because they are reluctant to believe that anything so simply made as the devices already described and illustrated can possibly work and carry out modern light-ray control. There are others, who, no doubt, will be thinking that there is some deeply hidden mystery or secret which only a super-skilled electrician understands, and which only he could produce; but in actual practice such fears and inhibitions

are entirely unfounded, and once a start is made in the field of electronic model railway control, the reader will be surprised what successes can be achieved with even the most absurdly crude "lock-ups."

At this stage the reader will be naturally anxious to see what results are obtainable with the apparatus already constructed, so, assuming that a P.O. relay has been purchased, the "hook-up" shown in Fig. 96 may be tried out in the following manner.

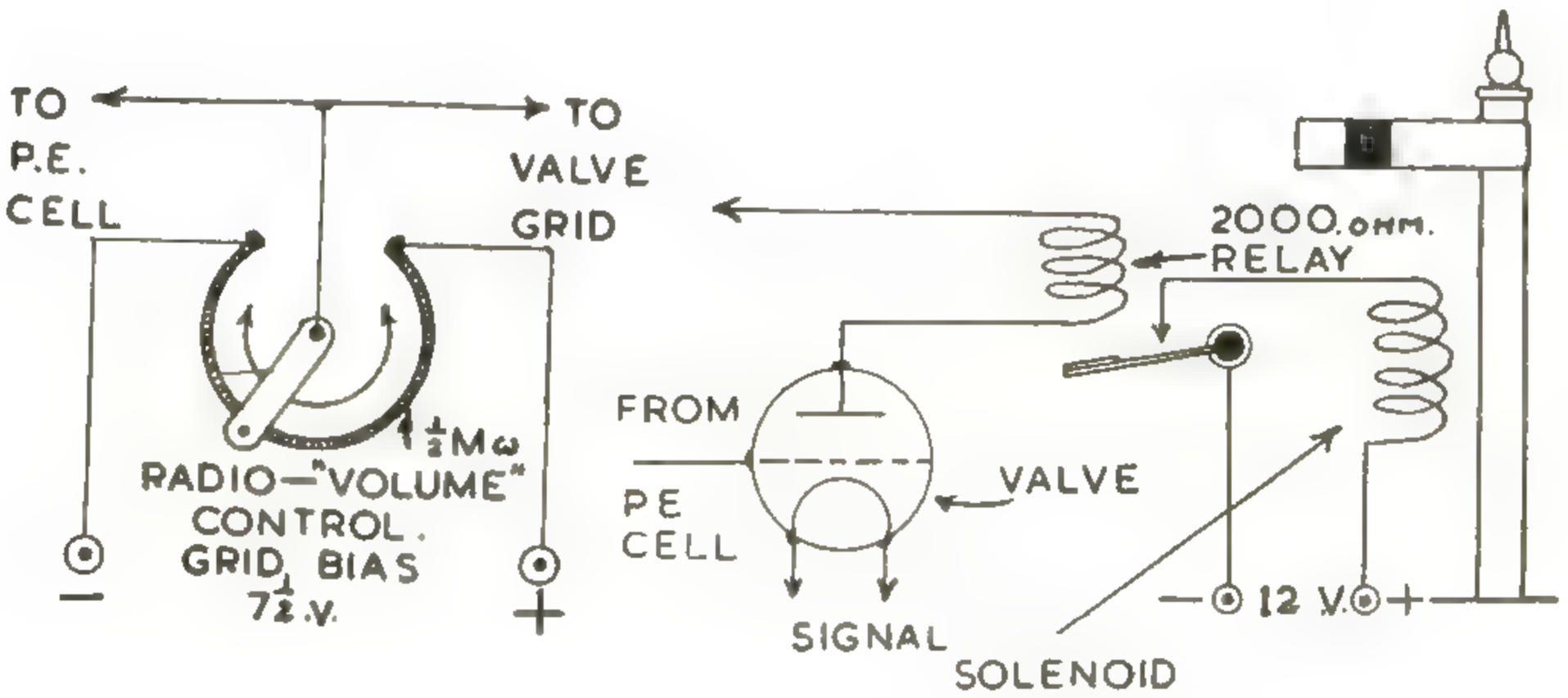


Fig. 96

In the case when the source of light is playing on the photo-cell, there is a definite anode (positive) potential on the cell and a definite potential on the grid of the valve, the latter still probably having a positive bias which is made negative by means of the grid bias battery. So by means of varying the grid bias (at the grid bias battery sockets) and the manipulation of the 30-ohm filament resistance, the anode current of the valve can be arranged so that it will *just not close* the relay. Then when light is cut off from the photo-cell, the valve grid becomes positively (or less negatively) charged, with the result that more current flows in the valve anode circuit and the relay contacts are closed. If the whole set up does not operate at first trial—and there is every likelihood that it will not—

the grid bias to the valve should be reduced (whilst leaving the filament resistance full on) until the relay is *just* not closed when the P.E. cell is shielded from its illuminant. In other words, with the P.E. cell covered it should be possible to operate the relay by varying the amount of grid bias on the valve, this bias acting as a kind of pre-set control.

When the correct setting has been found (with the P.E. cell shielded from its light) the relay should click over the

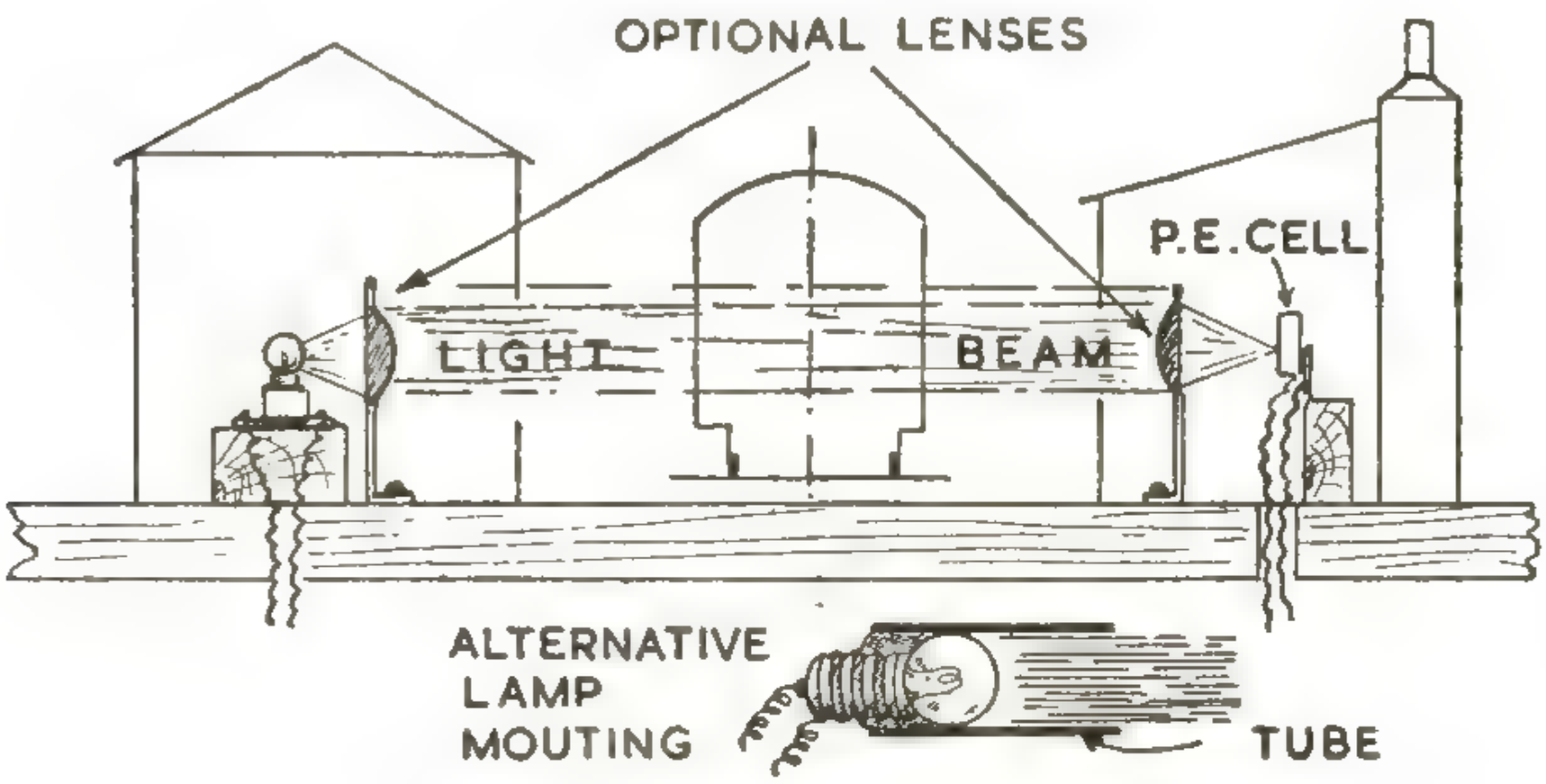


Fig. 97

instant light is allowed to reach the photo-cell. If it does not, then an extra 10 V should be added to the high-tension battery or the return spring of the relay slacked off slightly. A little patient experiment with various settings of grid bias and filament voltage will soon effect the setting of the valve amplifier; and once the correct setting is found, no further adjustments are necessary until the voltage of the high tension battery falls below a working level, this usually taking many months.

There is one very important matter which has not yet been noted, and that is the method of illumination required to operate the photo-cell; and here again, the very simplest of materials are needed, the lens being obtainable from a discarded electric hand-torch. As it is essential that the

cell should not operate by ordinary daylight or by the direct light of the lamp lighting the railway room, it is essential that it is housed in some way so that its active surface is shielded from light from all extraneous sources. To this end it must be mounted by the track-side as shown in Fig. 97, where it is accommodated well back in a platelayer's hut, the light from the lamp on the other side of the track shining in through the open door.

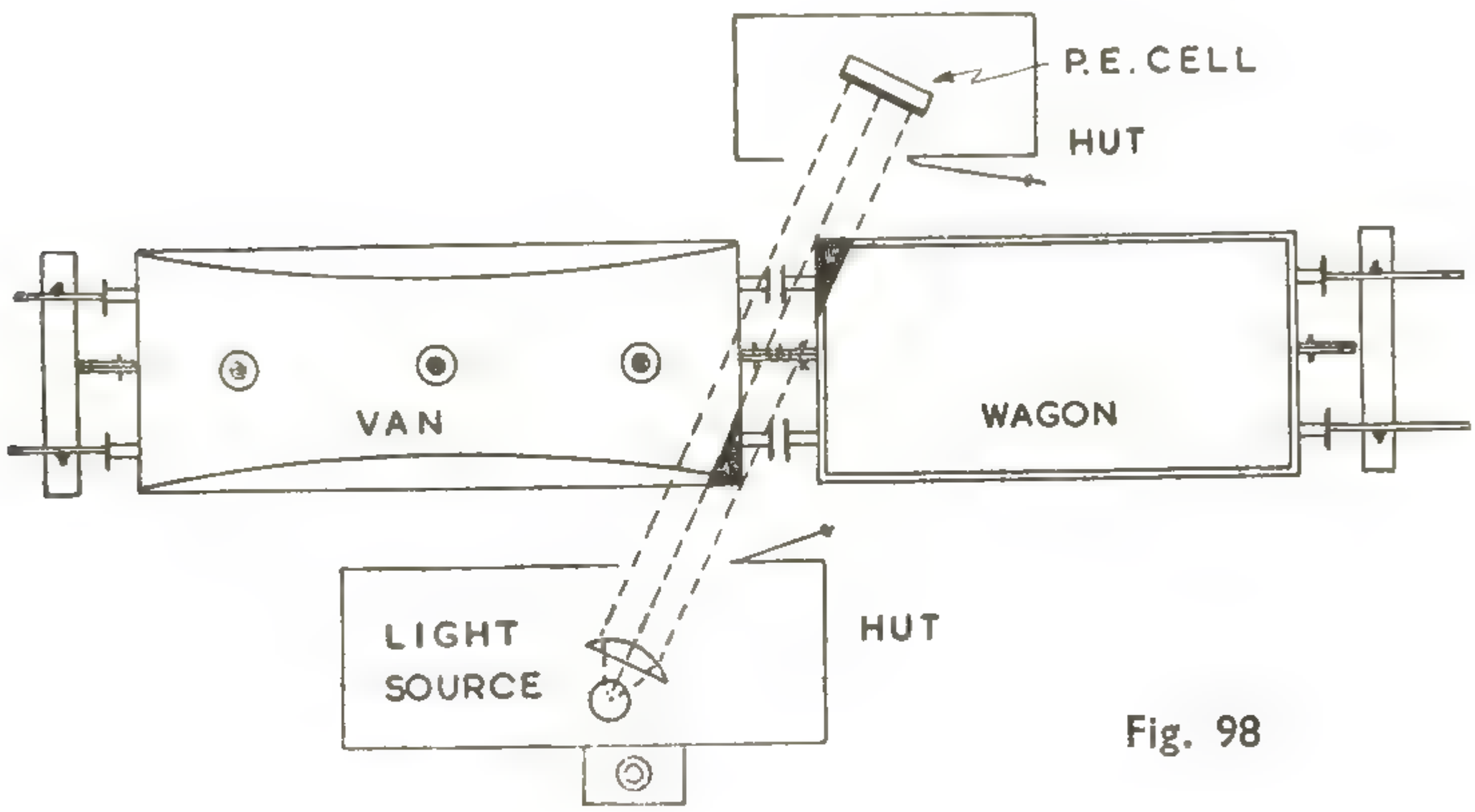


Fig. 98

The light source is fitted in a similar building, and consists of a 6-V car side lamp, supplied with either d.c. or a.c. current from any suitable source, the light rays being collected and parallelled by a plano-convex lens procured from the source already mentioned. The parallel beam of light must now be directed full on the sensitized face of the photo-cell, as shown.

It may be said that as a train passes the ray, the latter will be broken and completed as every individual vehicle passes, thus causing the relay to contact many times to each train. This is correct, and to obviate this, it is essential to slightly stagger the light source and the photo-cell, so that the ray cuts the line of track obliquely, as shown

in Fig. 98, so that even the most widely-coupled rolling-stock do not offer sufficient gap to allow the beam to pass.

All the previous circuits are designed for battery operation; but operation is possible from a.c. mains supply, which is really simpler than working with batteries, though, of course, it has, in a way, the disadvantage of necessitating the use of a mains transformer. A circuit for such operation is shown in Fig. 99, in which the relay and valve are fed with rectified a.c. current, or a 4- or 6-V " directly-heated " valve being used, such

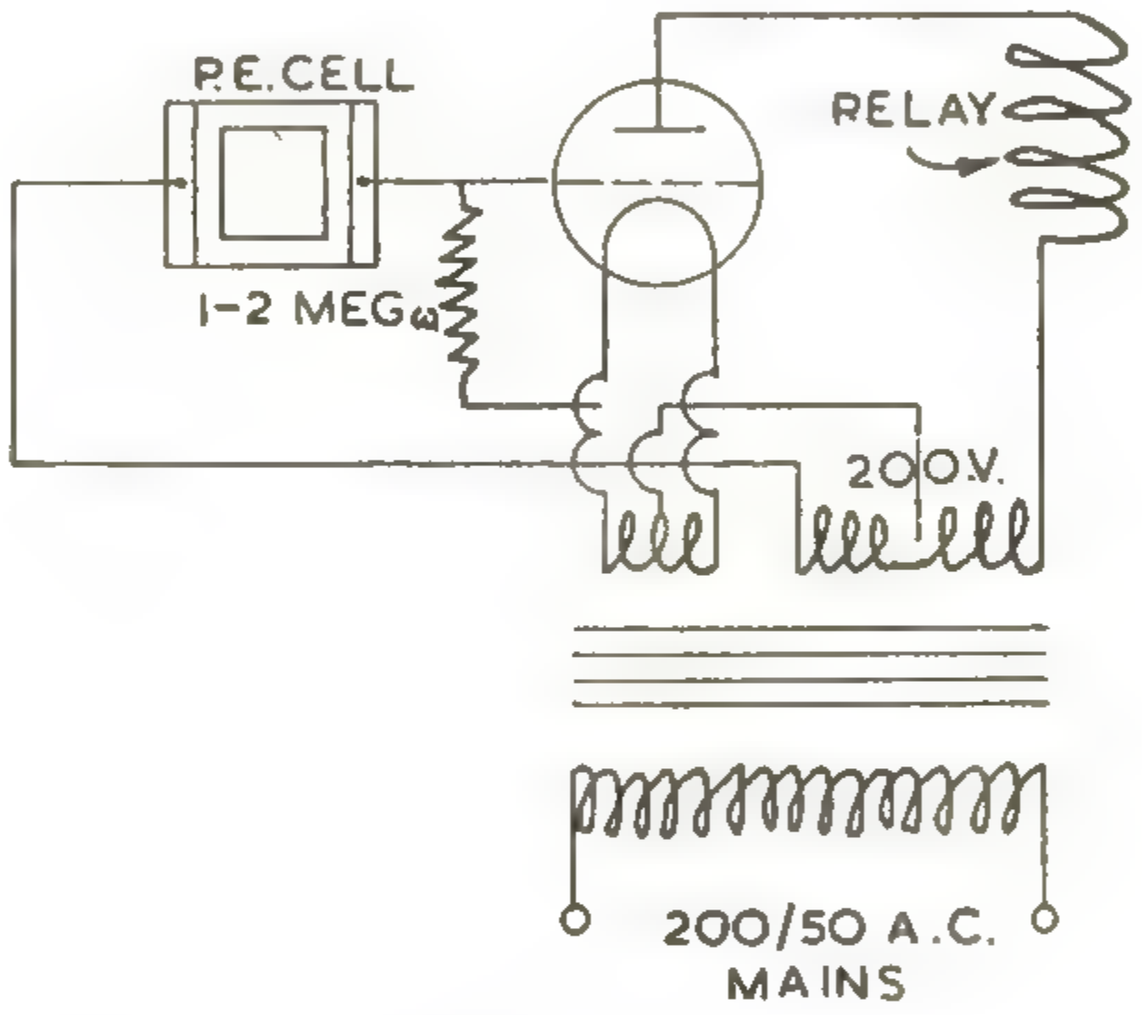


Fig. 99

as the Cossor 4XP, or Marconi-Osram PX4 being satisfactory, and obtainable at almost any radio store. The rectification of the a.c. is carried out automatically by the valve itself and the photo-cell, as the a.c. is positive for one-half of its cycle and negative for the other; so that at each half cycle the valve (and P.E. cell) anode will be negative in respect to the cathode, and thus no current will flow.

As mentioned at the beginning of the chapter, photo-cells are of two main types—the true " cell " or generator and the " resistance " or selenium type ; and it is with the latter that we have been dealing so far. The reason for

the choice of the selenium and "rectifier" types was to provide a simple and reasonably-priced light sensitive cell suitable for the straightforward "light-dark" operation required for model railway operation. The way in which this type lends itself to amateur home construction and experiment was also taken into consideration when the choice was made. It will, however, be appreciated that, if cost is not the greatest consideration, the quickest way

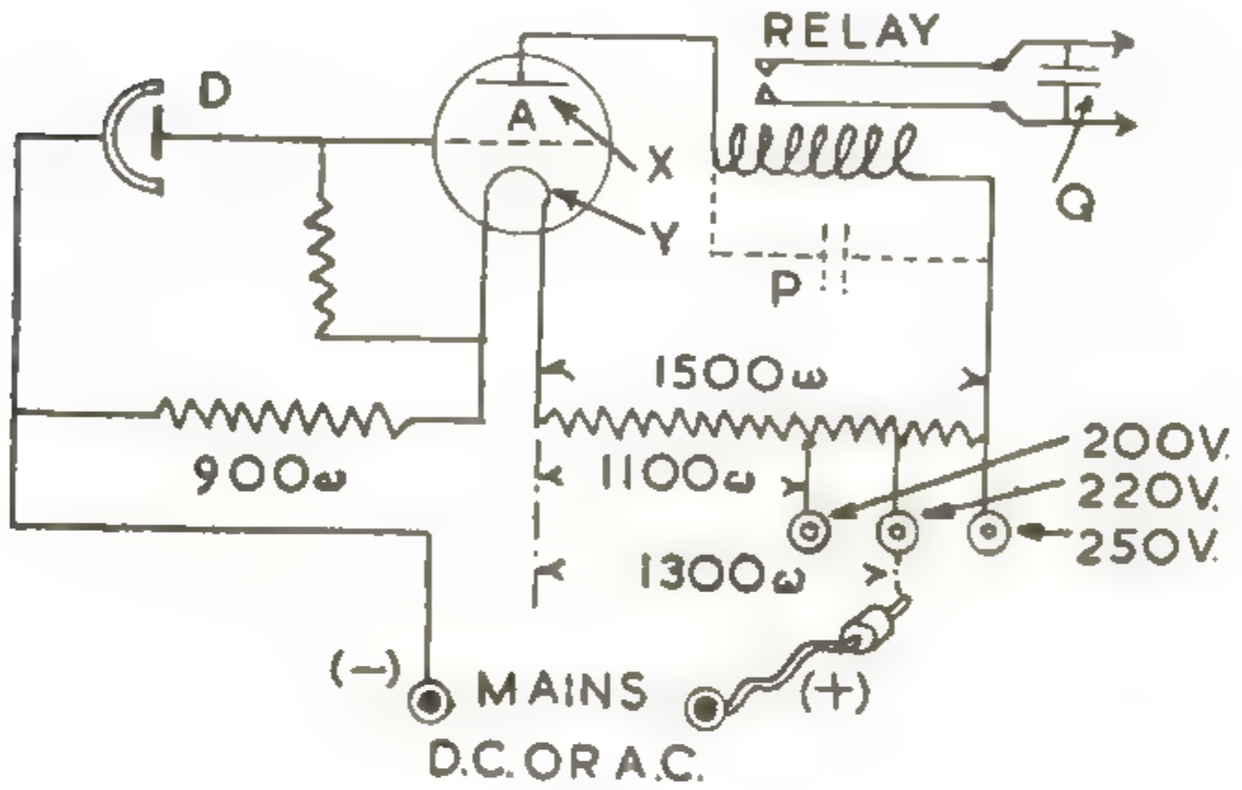


Fig. 100

of setting up a system of electronic photo-control is by purchasing ready-made one of the vacuum type photo-emissive cells of which a representative picture was shown in Fig. 78, and is of a G.E.C. Type CMG22 caesium/silver oxide gasfilled cell. These cells are, in effect, electron tubes having cathodes which emit electrons under the influence of light rays, and the output of such a cell may be amplified—in a similar way to that already described for selenium cells—by a valve or valves to about 10,000 times the output of the P.E. cell, so that it can operate a relay and so control any electrical device.

There are some slight differences in the electrical connections required by photo-emissive cells, and in Fig. 100 is shown the circuit necessary for a CMG22 cell and one valve amplifier operated direct from the main house supply. It will be noticed that the valve (which is a 4-V Osram 410 type) (*A*), has its filament in series with two resistances

the longer one of which is tapped to suit various supply voltages from 200 to 250 a.c. or d.c. The photo-cell (*D*) has its cathode connected to the main supply, and its anode to the grid of the valve, whilst the relay coil is connected in the anode circuit of the valve. The voltage-drop across the 1,500 W resistance gives the necessary anode voltage for the valve, and that across the 900 W one the polarising voltage for the photo-cell.

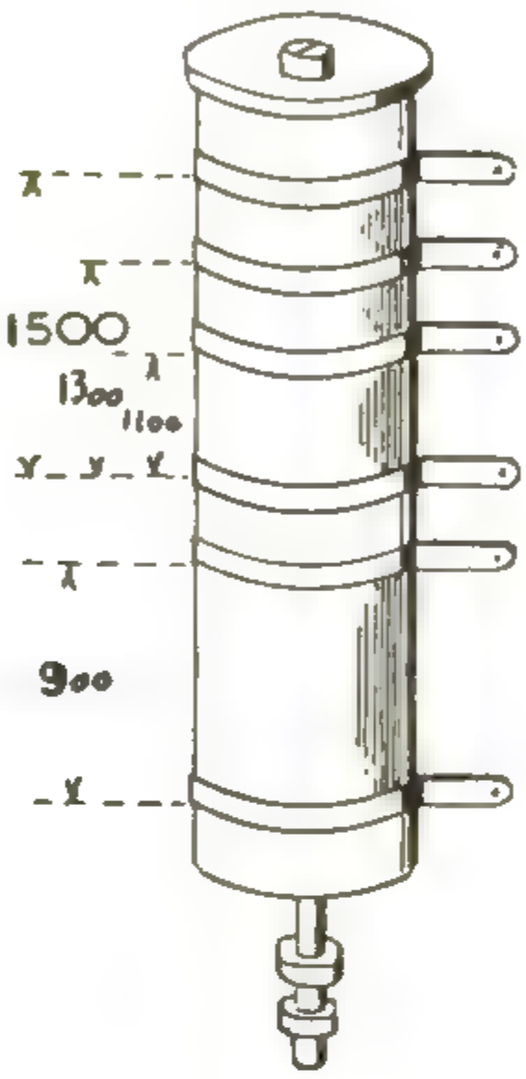
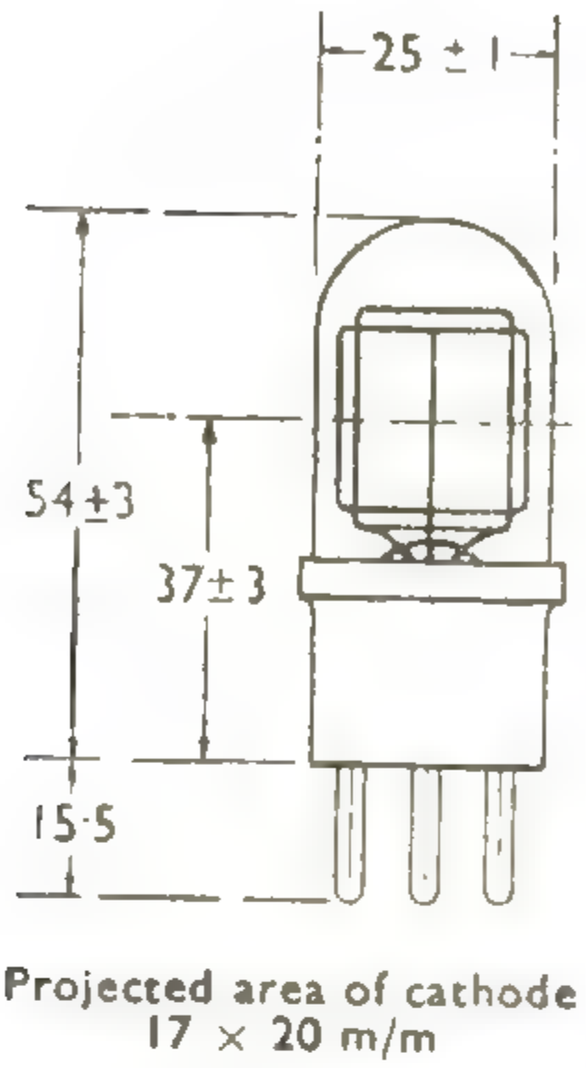


Fig. 101

The operation of the photo-emissive cell is very similar to that already described, with the difference that current is actually generated by the cell under the influence of impinging light rays. Assuming that the main supply is direct current (d.c.), and the photo-cell is in darkness, the difference in potential between the anode and filament of the valve (*X* and *Y* in Fig. 100) will cause a current of about 8 mA to flow through the relay and keep its contacts either closed or open, as required (see also Fig. 103). As soon as a light falls on the cathode of the photo-cell, the electron emission will charge the valve grid negatively, and thus stop the anode current flow through the relay coil, which will then release its armature and close (or open, as required) the relay contacts.

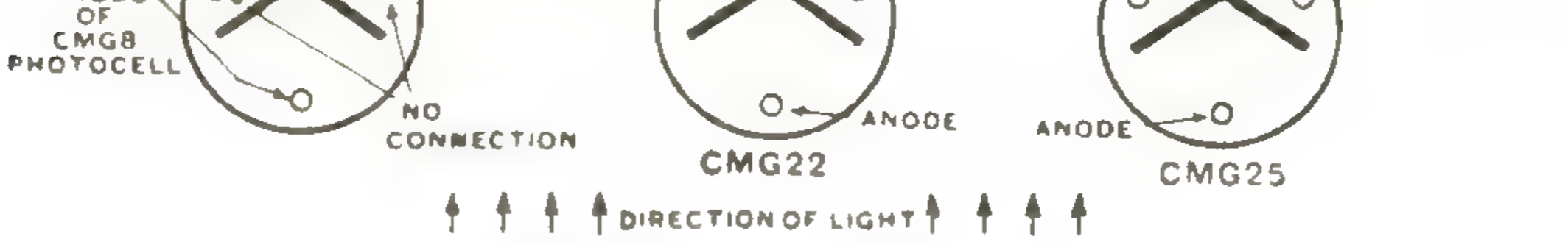
If the main supply is alternating current (a.c.), only the positive half of the alternation is effective in operating the circuit; for, in exactly the same way as described previously, the valve and photo-cell act as their own rectifiers, turning the a.c. to d.c. The high-resistance grid-leak allows the grid charge of electricity to leak away when light is shut off from the cell, and thus restores the circuit to its original condition.

Both the 1,500 W and the 900 W resistances must be of



Projected area of cathode
17 × 20 m/m

the vitreous enamelled type, of the values shown, and capable of carrying one-tenth of an ampere continuously. The 1,500-ohm resistance should be tapped at 1,100 and 1,300 ohms, respectively, where shown. Such resistances are purchasable as voltage droppers for a.c./d.c. radio sets, and an average type is shown in Fig. 101. It is important that the tapped 1,500-ohm resistance should be on the positive side of the mains if they are d.c., and that the tap-



View looking on underside of bases.
Courtesy of G.E.C.

Fig. 102

pings are used according to the supply voltage. If this precaution is not taken, the life of the photo-cell and its valve will be considerably reduced. Too high a voltage will produce a dim blue light in the photo-cell which, if not immediately reduced by opening the circuit, will permanently damage the cell.

In Fig. 102 are shown the dimensions of the Osram CMG22 photo-cell together with the pin arrangements at its lower end, and, as will be seen, it fits into a normal 4-pin radio valve-holder. In fact, all the other components

in the amplifier are standard radio parts and need no description. In mounting the components, care should be taken to ensure that the connection between the photo-cell anode and the grid of the valve is kept as short as

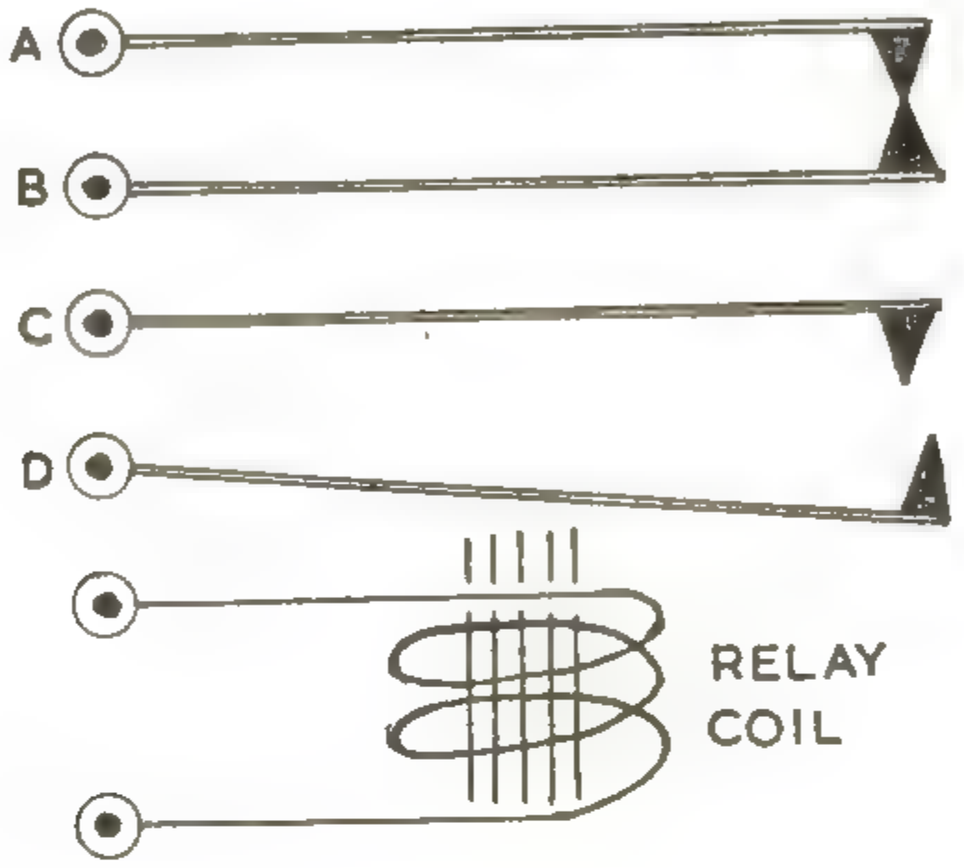


Fig. 103

possible; this is particularly necessary when working on a.c. mains supply, as otherwise, induced currents between the grid and some other part of the circuit may produce queer effects which will cause the set to operate very indifferently. The relay should be fastened down in a horizontal position, as shown in Fig. 95.

To enable a photo-cell to do useful work in signalling a model railway, the relay used must be provided with at least two pairs of contacts, as shown in Fig. 103 ; these are so arranged that, when the armature of the relay is at rest, one pair is contacting and the other pair open-circuited. In the sketch, contacts *A* and *B* are made, and *C* and *D* broken; when the relay is energised, the reverse positions occur in which *A* and *B* are broken, and *C* and *D* made. By wiring *B* and *C* together, as shown in Fig. 104, and taking a lead from *A* to the red lamp of a colour-light signal, and from *D* to the green lamp, the normal position of the relay (i.e., when light is shining on the

controlling photo-cell) will permit the red signal to show; but when the light-ray to the cell is interrupted by a train, the relay will become energised, and cause the red light to be extinguished and the green to be exhibited. Green will continue to show until the last vehicle of the train has passed the light-ray.

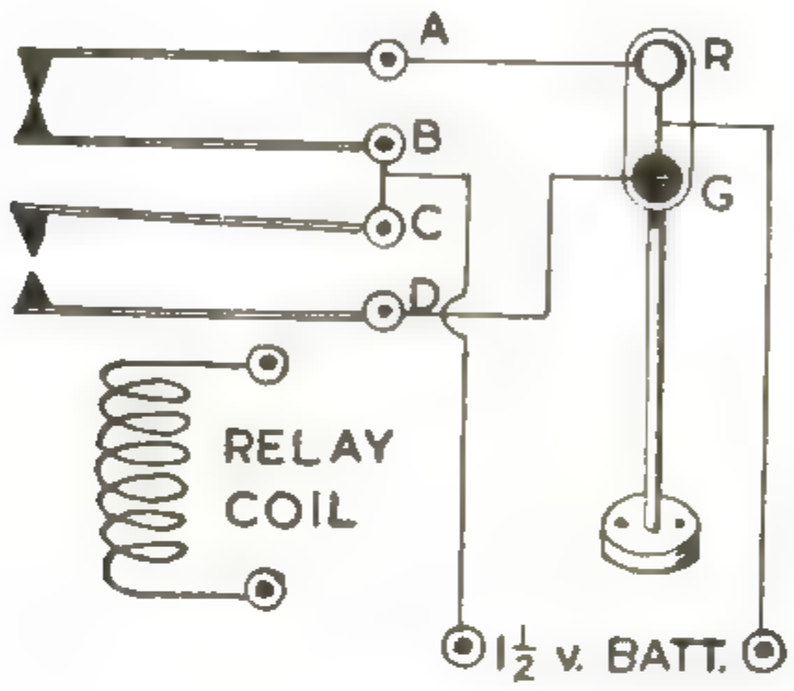


Fig. 104

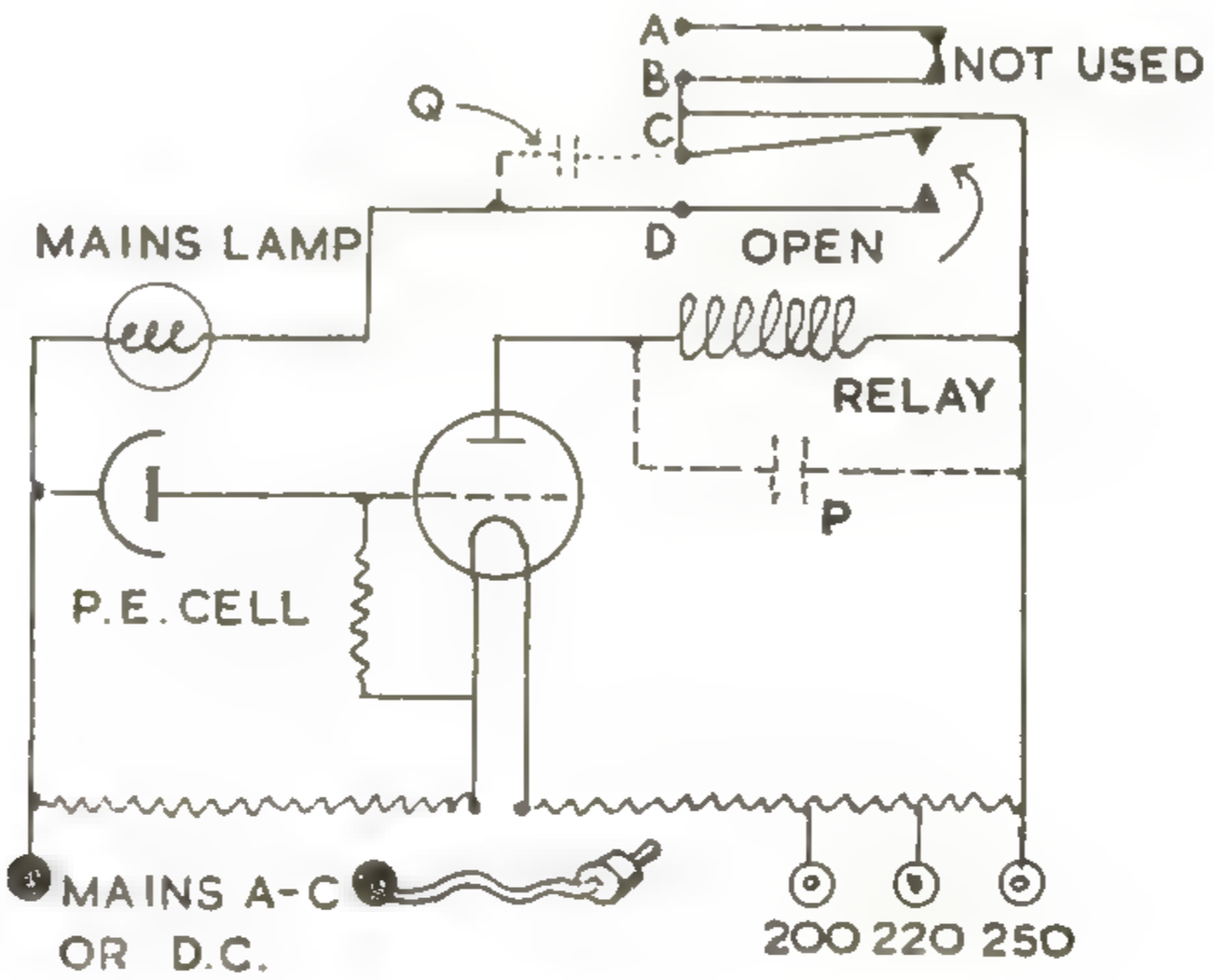
A simpler indicator circuit, which will give a lamp or buzzer indication at the control desk when a train passes a protected point, is shown in Fig. 105, in which only one pair of relay contacts are used, the lamp being of mains voltage and of 15 or 20 W.

On Figs. 100 and 105, two condensers (*P* and *Q*) are shown dotted. These are shown in case the useful work done should entail the lighting of a mains-voltage lamp or other apparatus at mains voltage, in which case, if the supply is a.c., the position *P* should be used for a 4-microfarad paper condenser, and if the supply is d.c. position *Q* should be filled by a condenser of the same capacity. If it is desired that the lamp or other apparatus should

function when light falls on the photo-cell (i.e., in the reverse way to that of Fig. 105 circuit), then terminals *A* and *B* are used, instead of *C* and *D*—as shown in Fig. 105.

In cases where it is required that the lamp, bell or buzzer should ring continuously once the exciting light-beam has been broken, the circuit of Fig. 106 should be

Fig. 105



used; in this the anode circuit to the valve (*via* the relay coil) is closed by a manual switch. As soon as the relay is energised, contacts *A* and *B* open, and switch the photo-cell out of circuit, the anode current of the valve keeping contacts *C* and *D* closed until the anode circuit is broken by opening the switch (*S*), which, of course, must be closed again to put the set in readiness for the next operation. This is the circuit used for burglar-alarms, where a bell is required to continue ringing after the exciting beam has been once interrupted.

To produce the reverse effect to that given by circuit Fig. 106, (i.e., that the indicator lamp will remain on permanently *after light* has fallen on the photo-cell) the circuit shown in Fig. 107 is used. In this case, assuming

the cell to be dark, the circuit can be set by momentarily closing switch (*S*), when contacts *C* and *D* close, and the valve anode circuit is completed through them even after the switch (*S*) is opened again. At the same time as *C* and *D* close, contacts *A* and *B* open—ready for operation.

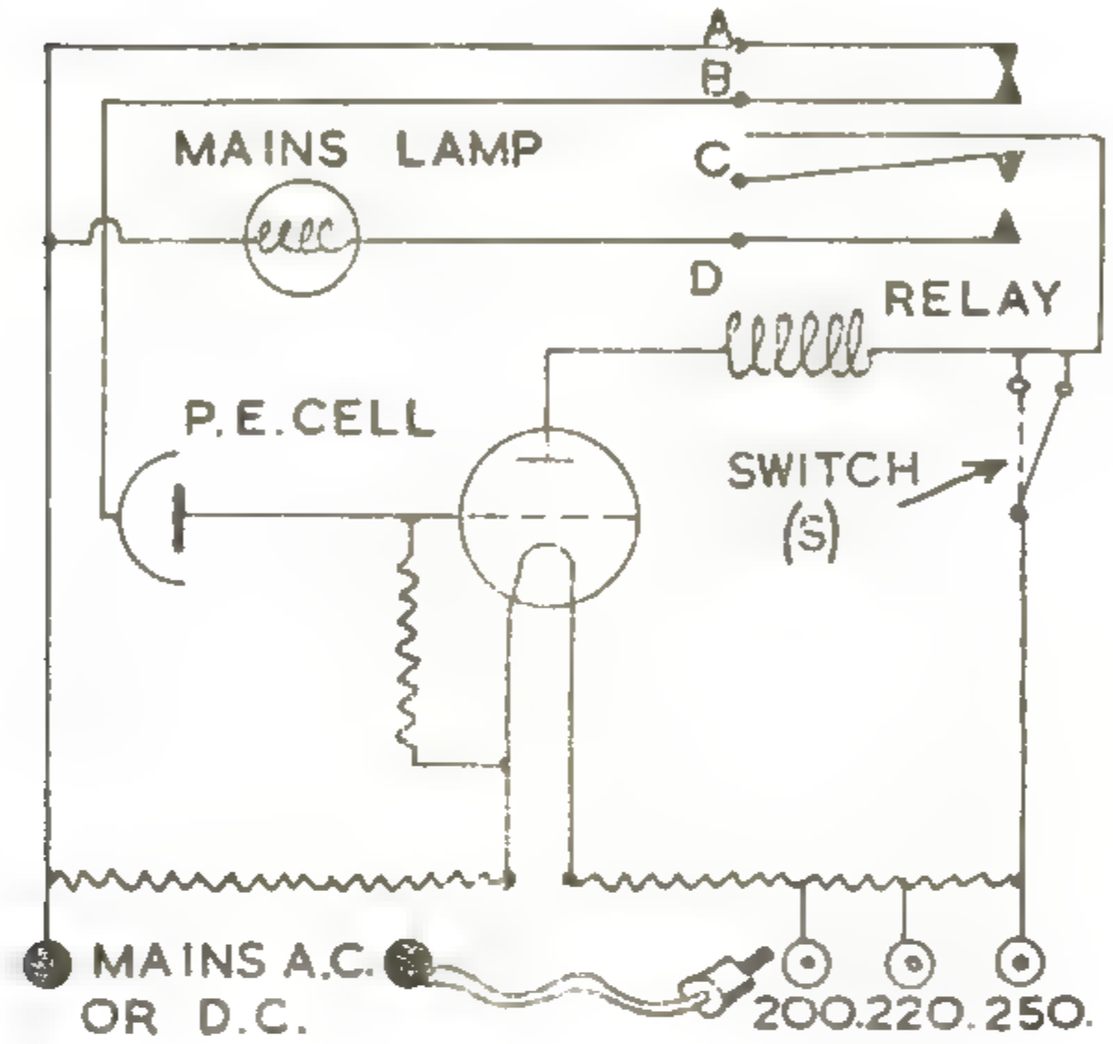


Fig. 106

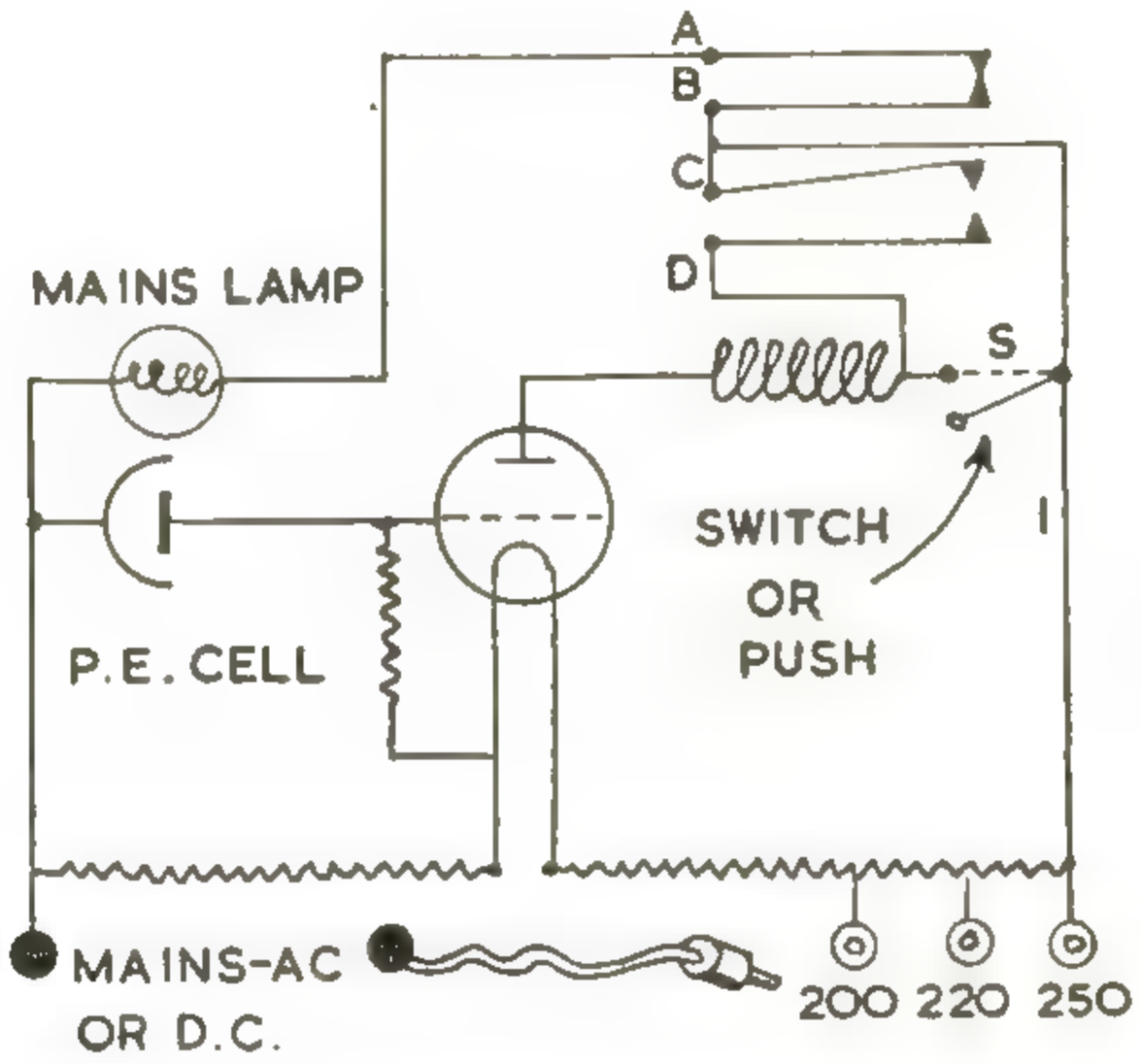
When light falls on the photo-cell the anode circuit is broken at contacts *C*-*D*, and the relay returns to normal—(i.e., with contacts *A* and *B* closed) until reset by the switch (*S*). This circuit is also used for a burglar alarm in which a warning bell rings even if the intruder switches off the lights in an attempt to stop the alarm.

In model railway work it is not generally desirable to have lamps or other apparatus of mains voltage in use, and it thus becomes advisable—one might almost say imperative—to modify the circuits shown in Figs. 100, 105, 106 and 107, so that an independent low-voltage source of local power is used on the blades of the relay, and one such circuit is shown in Figs. 104. The modification necessary on the other four circuits noted is shown in Fig. 108, where a local battery is used, and in Fig. 108A,

in which rectified low-voltage a.c. does the work. (See also chapter 2, Figs. 24 to 29, and relative text).

These circuits are given to indicate some of the many ways in which emissive cells (and selenium cells) can be usefully employed, and it must be remembered that they are capable of numerous modifications to suit particular

Fig. 107



jobs, providing the model railway experimenter with entirely new ground, on which to display both ingenuity and skill. For example, by substituting the lamp in Fig. 105, by an electro magnetic counter, the number of vehicles passing through the light beam can be counted; the light source and photo-cell in this case are ranged exactly on opposite sides of the track. Again, a photo-cell can be used for counting the number of runs made by a train on a large layout, or, by arranging the blades of the relay to cut off the traction current, a train can be made to stop itself at a given point on every circuit of the track.

These, and many other equally intriguing devices can be planned and operated without interfering in any way

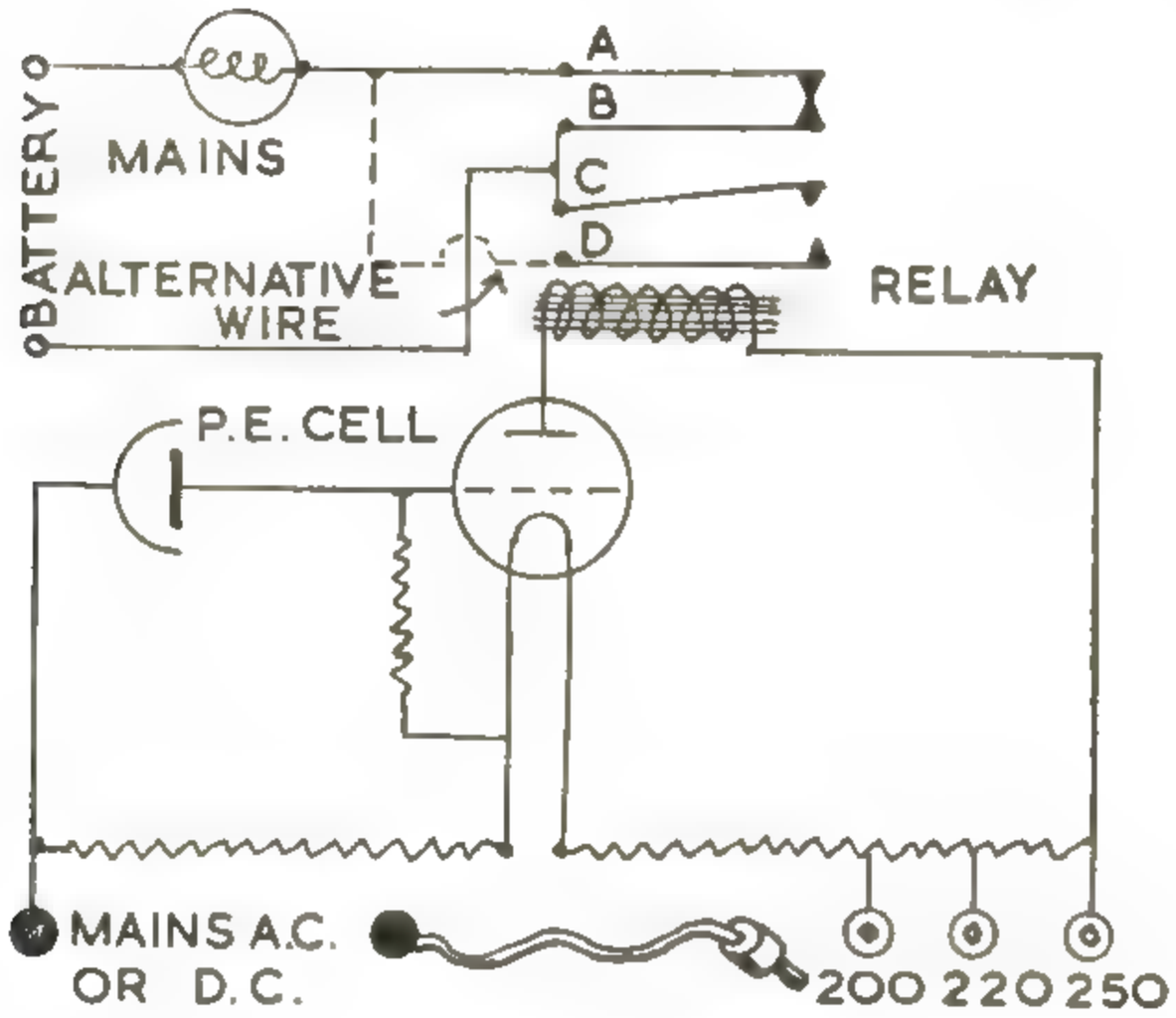


Fig. 108

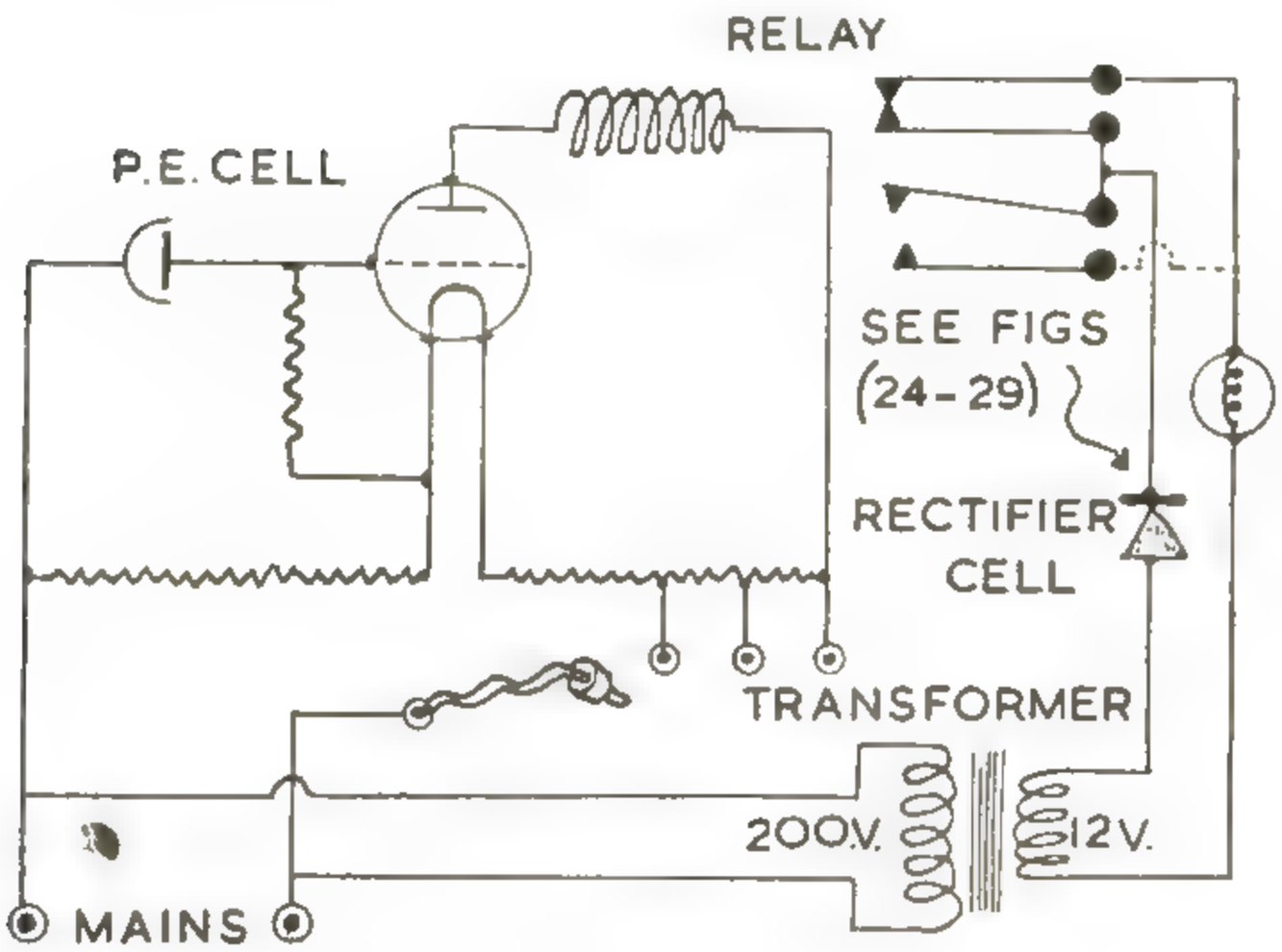


Fig. 108A

with existing signalling apparatus, and are applicable to either two-rail, three-rail, stud-contact or clockwork lines, without the fitting of any extra track contacts or ramps. Electronic control devices are completely dissociated from, and yet supplementary to *any* existing form of signalling or control used on model railways.

CHAPTER EIGHT

AS relays are so exceptionally useful—in fact, indispensable—in all classes of model railway power signalling, and it is easily possible to make them successfully from materials usually found in the average workshop, this chapter will be devoted to giving a general idea of the construction and adjustment of two sturdy types of relay which can be used with every confidence for model railway work.

Although motor-car auto-cut-outs are, in a sense, adaptable to model railway uses (so long as they are used in d.c. circuits), there is a great deal to be said for the relay which is specifically designed for the work it has to perform, and can easily be made by the average model railway engineer at home in his workshop; and it will be shown that the constructional work necessary is neither difficult nor to excessively fine limits.

By studying Fig. 109, a general idea of the layout of the first type of relay to be constructed will be gained. The operating bobbin is mounted horizontally, being supported in place by its core, the latter being screwed at one end to the vertical portion of a bent soft-iron base (*B*). Another piece of soft-iron is screwed to the other end of the core, and this is brought to within 1/32 in. of the turned-up end of the bent base (*B*), the gap being shown on the side-elevation diagram. Thus, when the core is magnetised by the winding, an intense magnetic field is formed across the gap, to which the blade of the relay is immediately drawn.

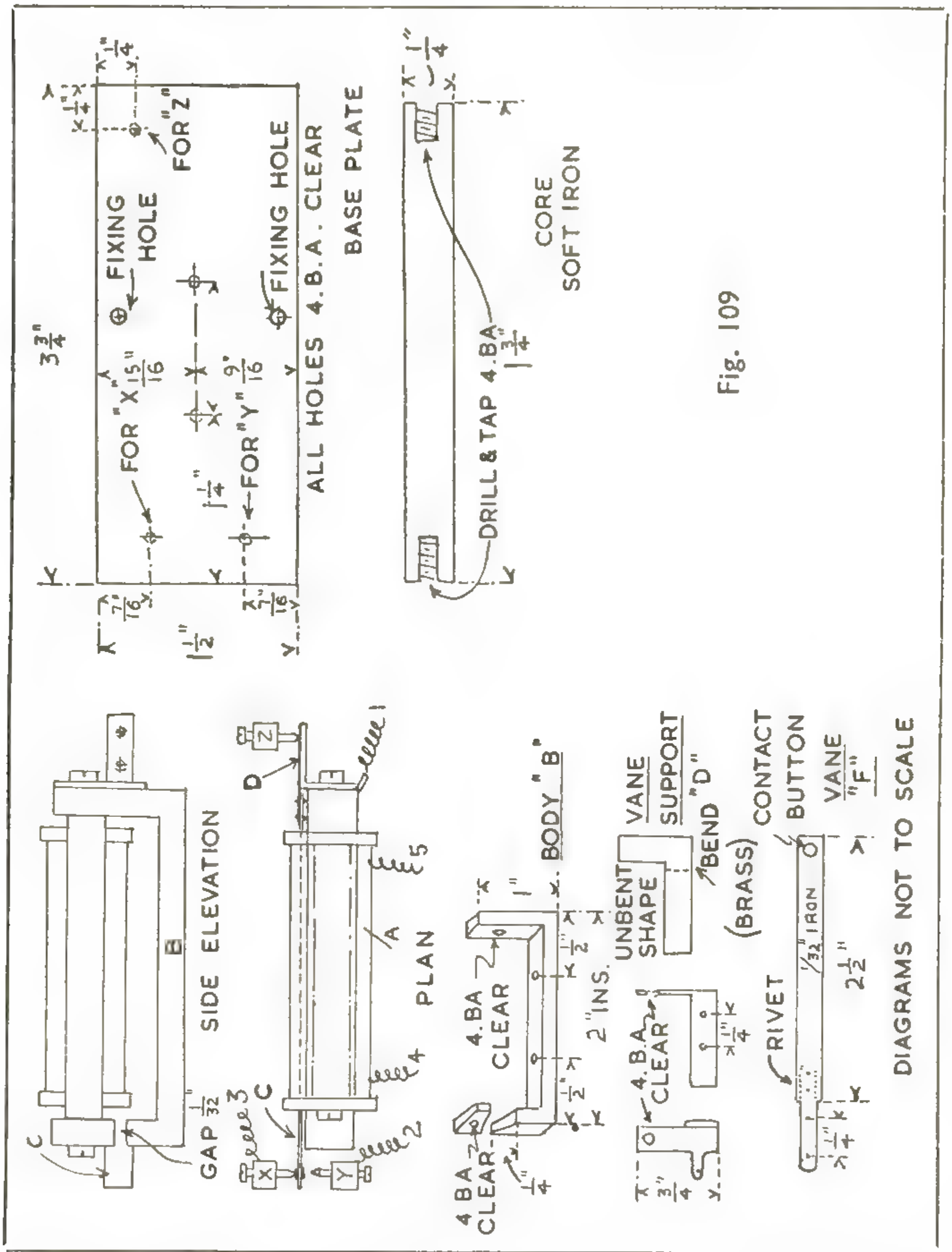


Fig. 109

The blade consists of a length of 1/32 in. × $\frac{1}{4}$ in. soft-iron, at one end of which is riveted a piece of thin clock-spring, the latter being bolted to a brass bracket (*D*), which is gripped under the bolt that secures the armature core to the base (*B*). This assembly therefore, enables the relay blade to be mounted so that its free end lies

across the magnetisable gap already mentioned, it being free to move to and fro, under the influence of the armature.

On either side of the blade are mounted two bent brass brackets (*X* and *Y*) which carry adjustable contact screws, the points of which are set to contact either side of the blade, according to its position. A further bent bracket (*Z*) carries an adjusting screw the duty of which is to give the blade a slight bias *away* from the gap, so that it contacts screw *X* when the relay is de-energised.

Now as to the construction of this relay. First, a piece of vulcanite, ebonite, or even good hard-wood $3\frac{3}{4}$ in. × $1\frac{1}{2}$ in. will be required, the thickness of which should be about $\frac{1}{4}$ in. This should be drilled as shown in Fig. 109, the centre-line of the soft-iron base (and, hence, the holes through which its securing screws pass) being $\frac{9}{16}$ in. from one edge and $\frac{15}{16}$ in. from the other. This offset is necessary to allow the relay blade to lie centrally above the base-plate which carries the whole assembly.

Secondly, a piece of $\frac{1}{4}$-in. × $\frac{1}{8}$-in. soft-iron is cleaned up with a file and bent as shown, care being taken to see that both bends are truly at right-angles. A 4-B.A. clearance hole (No. 27 drill, or 5/32 in.) should be drilled through the bent-up angle, through which a screw will pass to secure the core to the base. Two 4-B.A. tapping holes are also drilled through the flat part of *B*, into which are eventually screwed the bolts which secure the bent strip to the base-plate of the relay. These holes should be drilled with a No. 34 drill. If the latter is not available, a 7/64 in. drill can be used, though it is slightly smaller and the hole will need greater care in tapping.

It will be noted that the shorter bent end of the soft-iron core supporting bracket is filed off to an angle (see end elevation). This is to give the maximum magnetic flux at the point immediately opposite the end of the moving blade of the relay, and care must be taken to get this gap down to a minimum of 1/32 in. in width, the final filing

being done after the small portion of $\frac{1}{4}$-in. × $\frac{1}{8}$-in. soft-iron has been shaped, drilled No. 27 (4 B.A. clearance), and mounted at one end of the bobbin core.

This core is made from a $1\frac{3}{4}$-in. length of $\frac{1}{4}$-in. soft-iron rod, such a piece of material being readily to hand in the form of a 6-in. wire nail. The length is cut and the ends filed up square, each end then being centre-punched and drilled to a depth of about $\frac{1}{4}$ in. with a No. 34 drill, and tapped with a 4-B.A. butt tap.

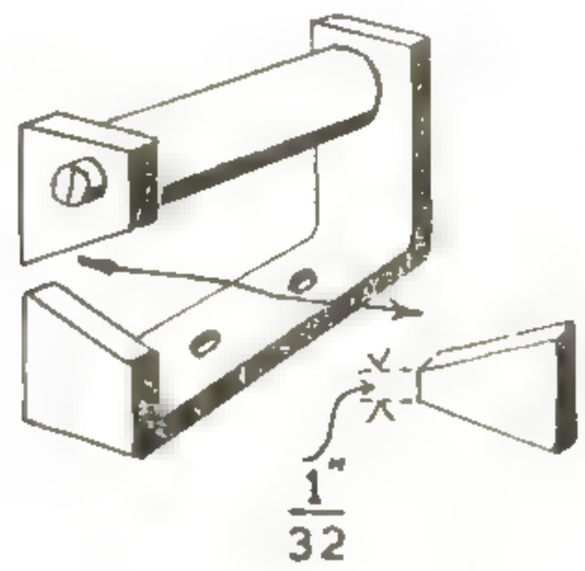


Fig. 110

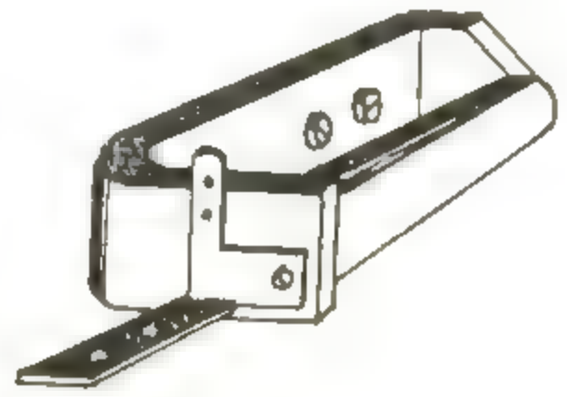


Fig. 111

A trial assembly of the core and its support may now be made, using 4-B.A. and $\frac{1}{4}$ in. cheese-head steel screws for fixing, and a check-up given to ensure that all is square and true. If desired, a wedge-shaped block of $\frac{1}{8}$-in. wood or ebonite, shaped as shown in the inset to Fig. 110, may be stuck with Chattertons compound into the gap to prevent any possibility of the latter closing when magnetised. The appearance of the assembly at this stage is shown in Fig. 110.

Next, the double-bent brass bracket (*D*) is made up from 1/32-in. (or No. 20 s.w.g.) hard brass, cut and trimmed to the measurements shown, its shape before bending being also illustrated. It should be drilled 4- and 6-B.A. where shown, and then secured by the same 4-B.A. screw that fixes the core to the longer angle of the soft-iron base. (See Fig. 111).

Now the blade (*F*) is made up from a piece of 1/32-in. soft-iron, $2\frac{1}{2}$ in. long and $\frac{1}{4}$ in. wide, two small holes being

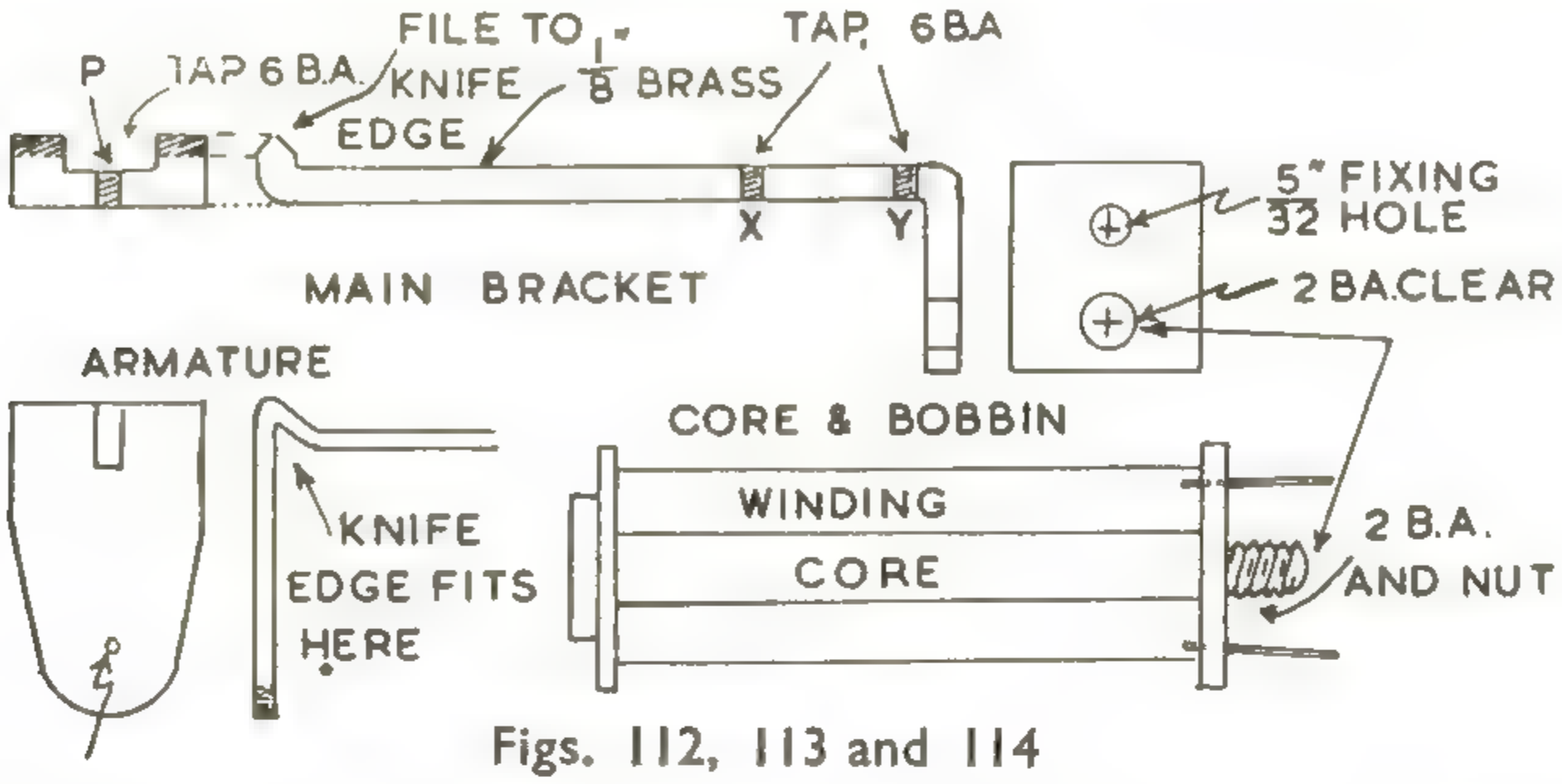
drilled at one end; these holes must be of a suitable size to take rivets made from short pieces of No. 16 s.w.g. copper wire, whilst at the other end a $\frac{1}{16}$-in. hole is drilled through which is passed a small piece of silver wire of the same size. This may be cut from the link of an old silver chain, or from an old watch-case, and should be made a tight fit in the hole before being riveted over on each side of the blade to form a double-sided button.

If a scrap of silver is not available, both sides of the blade should be " tinned " with solder where the contact button is to be mounted, and two small discs about 3/32 in. in diameter cut from an old gold or "Platignum " fountain-pen nib; these are sweated in place—one on each side of the blade.

A piece of thin clock-spring, $1\frac{1}{8}$ in. long by $\frac{3}{16}$ in. wide, is now required, through which are punched four holes, as shown; two of these holes must register with those at the tail-end of the blade already made. They must be large enough to take the copper wire rivets mentioned, and may be made quite easily by punching them out with a broken No. 52 drill, using a small block of lead as an anvil. It is important that the spring is not de-tempered and drilled. This completes the blade, which is now mounted on the double-bent bracket (*D*) by means of two short 6-B.A. cheese-head screws. Any slight adjustment necessary to ensure that the tip of the blade lies fairly in front of the magnetic gap should be made as these screws are tightened.

The relay now needs for its completion only the making and fitting of the three 1/32-in. angle-brackets (*X*, *Y* and *Z*), which are drilled and bent to 90 deg. as shown, *X* and *Y* carrying the contact screws (which are finely adjustable), and *Z* the regulator screw for biassing the blade away from the gap. These three brackets are mounted on the ebonite base-plate by 4-B.A. screws passed through the holes already made to receive them.

Adjustment of the relay mechanism can now be made. The contact screws at *X* and *Y* should be set so that their tapered points contact fairly in the centre of the silver



Figs. 112, 113 and 114

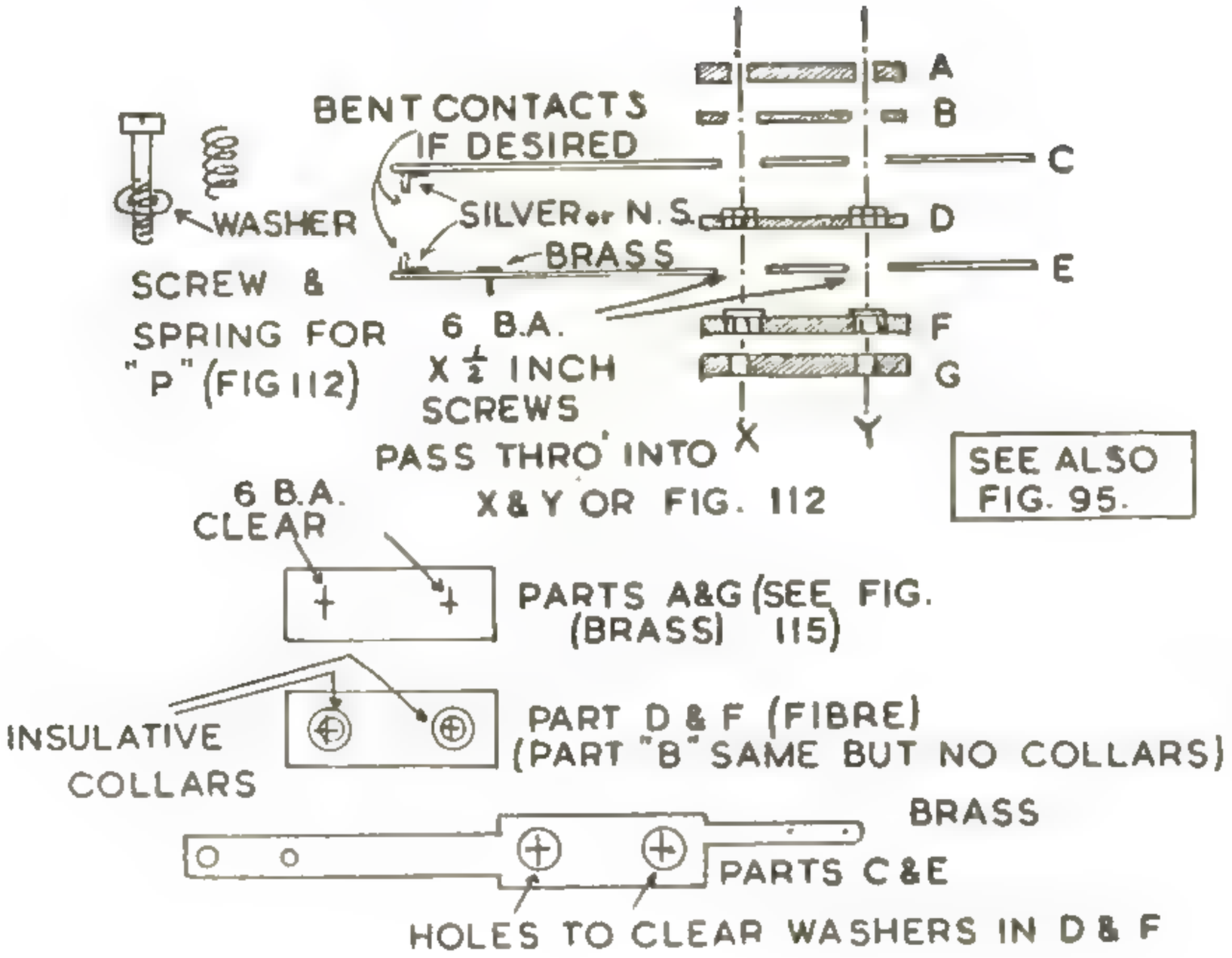
button in the blade, and the screw through bracket *Z* should be adjusted until the blade *just* presses firmly against screw *X*. (This latter adjustment is secured by the slight bending of the double-bent bracket (*D*), when screw *Z* is turned in a forward direction.)

There now remains the making and winding of the bobbin, the cheeks of which are 1½ in. apart and ¾ in. in diameter; neither of these figures is important. The bobbin may be made from cardboard or any strong non-conducting material, through which two small holes should be burnt with a hot needle to allow the wire with which the bobbin will be wound to pass through.

The bobbin is wound with No. 34 s.w.g. wire, to produce a total resistance of 100 ohms, 375 ft. or about 4/5ths oz. being needed to give this resistance. Other gauges of wire may be used, as follows:

Gauge	*Length*	*Weight*
*32 s.w.g.	600 ft.	2 ounces.
34 s.w.g.	375 ft.	4/5ths ounce.
36 s.w.g.	235 ft.	1/3rd ounce.

* Each of these windings will give a resistance of 100 ohms, but No. 34 is perhaps the best to use, as it is not too bulky and gives more ampere turns for its lengths than No. 36.



Figs. 115, 116 and 117

Relays such as that described may, if desired, be wired in series, and though this will throw the resistance rather high, it will halve the current consumption. There is no reason, however, why they cannot be wound for 200 ohms each.

The current consumption at various voltages is as follows:—

Resistance in ohms	*Supply voltage*	*Consumption in amperes*
100	9	0.08
100	10½	0.1
100	12	0.12
200	9	0.04
200	10½	0.05
200	12	0.06
400	9	0.022
400	10½	0.026
400	12	0.03

It will be seen from the above table that the higher the resistance of the bobbin, the lower will be the drain on the supply battery, and in the winding advised (i.e., 100 ohms, wound with No. 34 wire) the total drain is only 0.08 amperes (8 mA) at 9 V. In the prototype relay made, it was found possible to get a strong definite contact on the blades when working with a 3 V dry-cell.

In final adjustment, it should be observed that the contact on the moving blade touches contact screw *X* before the body of the blade reaches the pole-pieces of the magnet gap. If this is not arranged rightly, the blade is apt to stick to the gap due to the attraction of the residual magnetism being stronger than the return spring.

The layout of another very easily made relay is shown in Fig. 112, where it will be seen that the moving armature consists of an angularly-bent piece of soft-iron rocking on a knife-edge formed at one end of the main frame of the relay, which movement raises the contact blades which are firmly fixed at their other end by two insulated bolts.

Like the previous type this relay can be made easily from oddments usually to be found in that very useful collection—the scrap box. The main frame is made from a piece of $\frac{3}{4}$-in. $\times$ $\frac{1}{8}$-in. brass, a right-angled bend being made $\frac{3}{4}$ in. from one end, and a slight turn-up at the other, the latter bend being filed into a knife-edge, in the centre of which a flat is filed and a 6-B.A. tapping hole drilled. Two 4-B.A. tapping holes are drilled and tapped at the other end of the frame, where shown in Fig. 113, also a $\frac{5}{16}$ in. hole is drilled in the short arm of the bend.

The core for the bobbin is formed from a $\frac{3}{8}$-in. iron bolt the head of which is filed flat and covered with a disc of gummed parcel-tape. Two $\frac{3}{8}$-in. Whitworth nuts are required, one of which locks the bobbin on the bolt, and the other the bolt and bobbin to the main-frame. (See Fig. 114).

The bobbin is formed in precisely the same fashion as that already described for the other type of relay, being

wound as required from the information in the tables already given.

The method of assembly used for the relay blades is clearly shown in Fig. 115, which is an exploded view, from which it will be seen that each ebonite or hardwood spacer is drilled to clear 2 B.A. (No. 12 or $\frac{3}{16}$), so that short pieces of Systoflex or P.V.C. sleeving can be slipped over the 4 B.A. bolts used to grip the assembly to the main-frame, thereby insulating each individual blade from its neighbour and from the two bolts.

After screwing down the blade assembly, the projecting blade (No. 1) should be slightly bent with long-nosed pliers until it *just* presses down on to the armature lifting-stud and is, at the same time, just out of contact with blade No. 3, whilst still touching No. 2. Three blades are shown in this relay so that a secondary circuit can be either made or broken when the relay coil is energised, according to the connections made to the blades. If made between No. 1 and No. 2, the circuit will be broken, and if between No. 1 and No. 3, it will be made when the relay goes over.

This type of relay should always be mounted with the blade assembly on top of the coil, as shown in Fig. 112, and mounting in groups can be carried out quite easily by the use of a longer $\frac{3}{8}$-in. bolt, and a third nut as shown in Fig. 114. It is, in fact, a good plan to mount all the relays in this way, placing them together, with all those relating to one section or block next to each other; then, if any trouble develops in any one circuit, it is more easily located than if the relays were scattered all over the layout.

Further assistance can be given—when "trouble shooting"—by using differently-coloured wires for each section or block, and running them to proper terminal-strips having soldering-tags. The additional expense is negligible, and both coloured wires (in multi-wire cables) and terminal strips are obtainable from at least one advertiser in the *Model Railway News*, who specialises in model railway electrical apparatus.

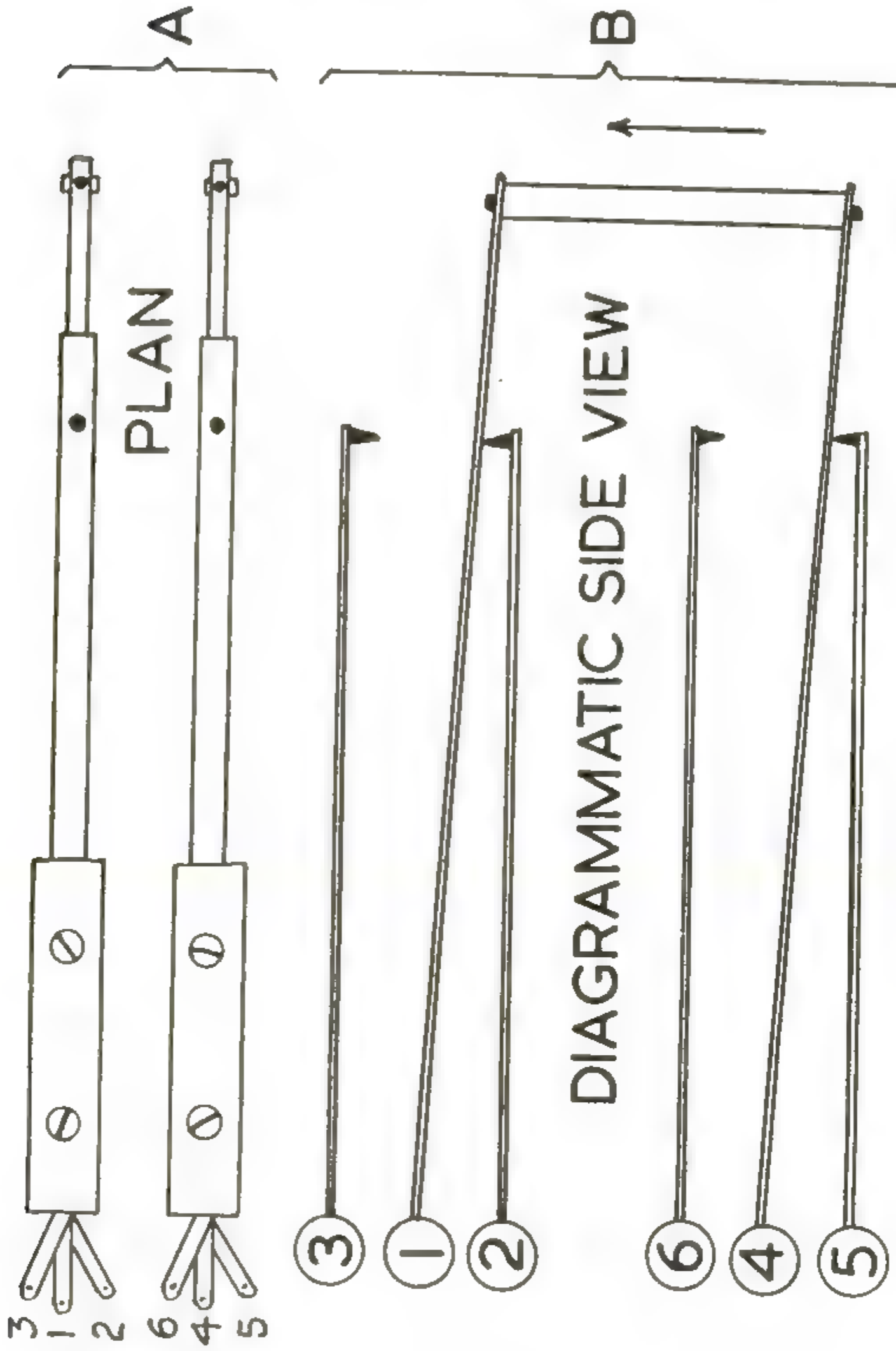


Fig. 118

In certain circuits, it may be necessary to arrange for one relay to make or break two entirely independent circuits at the same time, or to make one circuit and break another independent one at once. In this case, it will be necessary to arrange two sets of contacts side by side, mounting them on the main-frame of the relay as shown in plan in Fig. 118, the two longer blades (*A* and *B*) pressing down on to the armature, and being both lifted by it at the same time.

In the lower half of the diagram, the six blades are

shown in side view, and it will be observed that when the armature rises (relay energised), blades No. 1 and No. 4 are raised into contact with Nos. 3 and 6, contact with Nos. 2 and 5 being at the same time broken. Thus one circuit, flowing through Nos. 4 and 5 is broken at the same time as another through Nos. 1 and 3 is made, and *vice versa*.

Relays fitted with two or three sets of independent blades make the three-colour-light circuit illustrated in Fig. 119 possible; it operates entirely automatically, the signals exhibiting red, amber or green according to the position of the trains in the blocks covered. The signal block sections (numbered one to six, from left to right) coincide with the track-circuit sections (rail-breaks), the latter being placed about half a train's length ahead of the signals they operate. The track-circuits operate the coils of their respective relays, the sets of blades worked by each relay being shown diagrammatically at the top of the figure.

In operation, the normal (unoccupied) indication of all the signals is red, and a train approaching from the left, on entering the first automatic section (No. 1), energises relay 1 (not shown on diagram), and extinguishes the red in signal No. 1 (through blades *A*) whilst making the contact between blades *B*; thus permitting either the amber or green to show on signal No. 1 according to whether section 3 or 4 is occupied. If section 3 is occupied, then the amber will show on signal No. 1, and if section 4 is occupied, the green will light on signal No. 1. This selection between amber and green on signal No. 1 is brought about by one or other of the contacts *C*, on section 3 blades, or 3 on section 4, these contacts being back-wired to signal No. 1. The train having passed on into section 2, the red is relighted on signal No. 1 and extinguished on signal No. 2; either the amber or green of this signal showing according to whether section 4 or 5 is occupied, as already explained for signal No. 1.

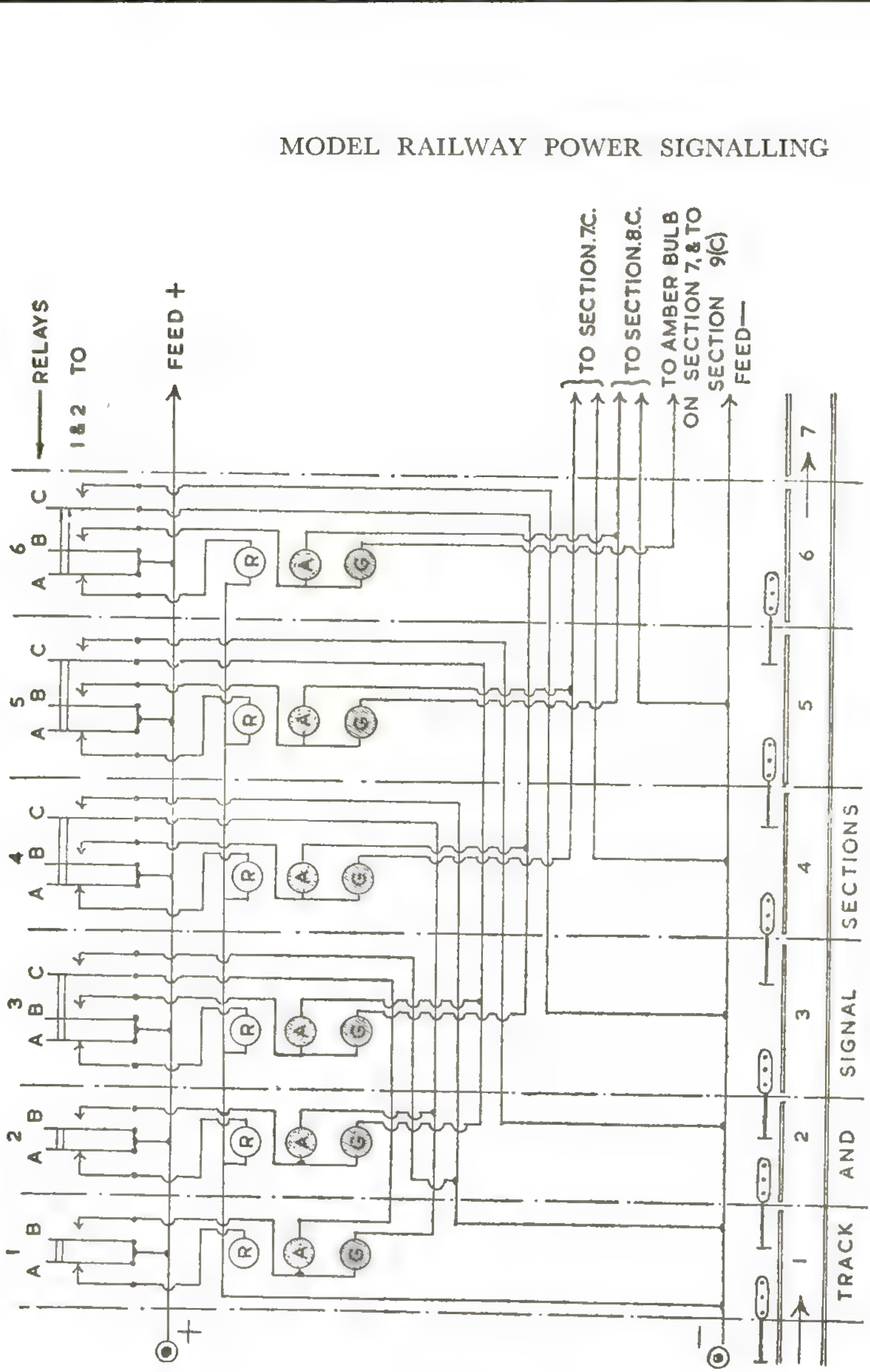

1&2 — RELAYS
TO
FEED +
TO SECTION.7.C.
TO SECTION.8.C.
TO AMBER BULB
ON SECTION 7,& TO
SECTION 9(C)
FEED—
SIGNAL SECTIONS AND TRACK
1
2
3
4
5
6
7
A
B
C
R
A
G
+
—

Fig. 119

It will be seen that back-switching takes place all down the line, the reds being successively extinguished, and either the ambers or greens illuminated according to whether the train ahead is two or three blocks in advance of the second train. Thus, if there is but one unoccupied block between the trains the amber will be exhibited to train No. 2, and if there are two clear blocks, the green signal will show.

Fig. 119 may look very complicated, but the wiring appears involved by reason of the diagram being compressed in proportion to the size and space available on the actual layout in which the wiring would be much more spread out, and "get-at-able." In point of fact, five wires are needed to each colour-light signal head, instead of the normal four used with ordinary switch-operation. The relay blades in Fig. 119 are shown as they would be if the track was entirely unoccupied.

A system of power signalling applicable to "two-rail" working is shown in Fig. 120, in which low-resistance (5-ohm) coils are used for the exciting coils of the relays, through which passes the whole of the traction current to the locomotive motors. When the relays go over, the appropriate battery circuit is switched in and operates normal high-resistance signal solenoid motors.

In operation, a train approaching from the left and entering section No. 1, draws its traction current *via* relay coil No. 1, and thereby closes blades *A* and *B*, and opens *C* and *D*; but it cannot operate relay No. 1 unless the next section but one is unoccupied by a moving train, when blades *C* and *D* of section No. 3 would be closed. If these blades were open (as would be the case were section No. 2 occupied) then the power supply to section No. 1 would be broken at point "*X*" in that circuit.

This back-switching is continued as the trains progress, a train two sections ahead cutting the power supply to the two sections in the rear, thus preserving two clear

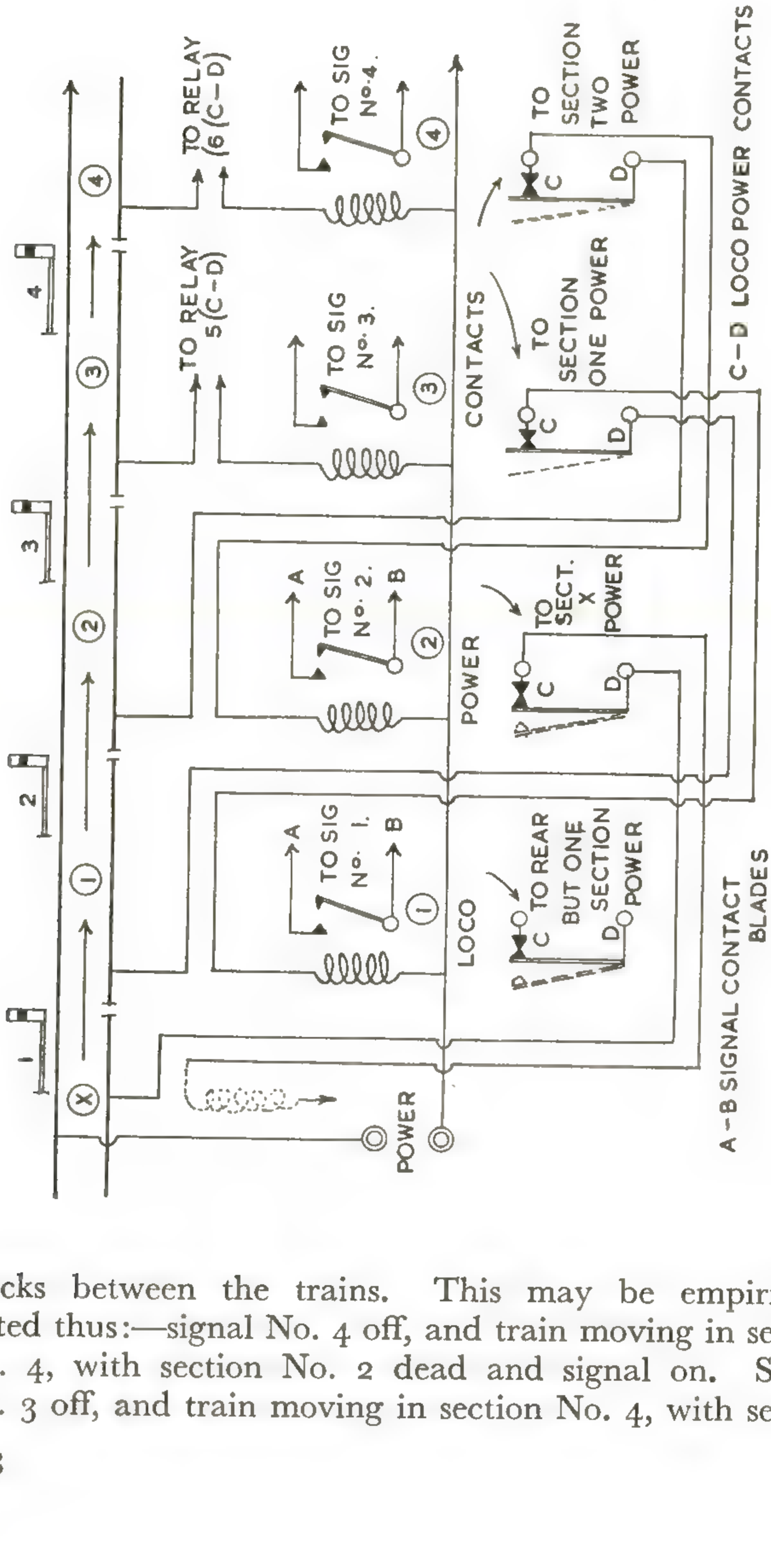


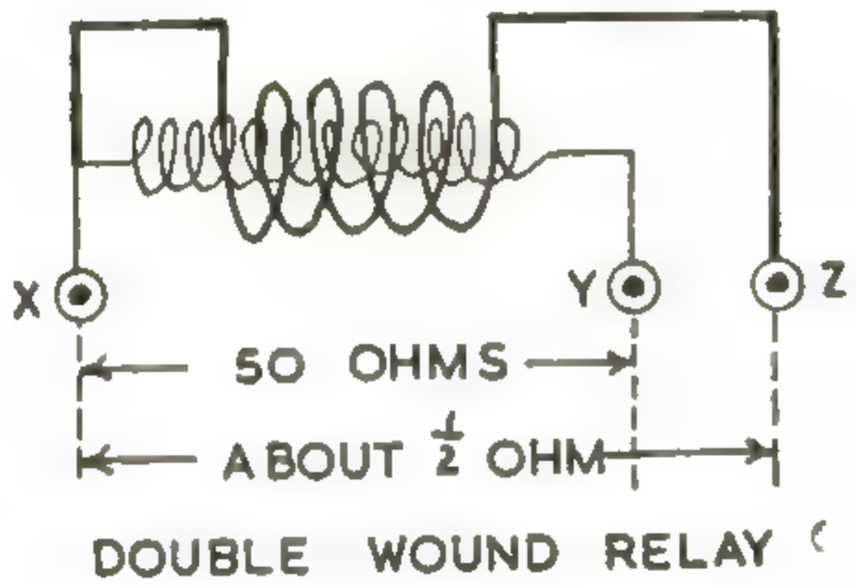
Fig. 120

blocks between the trains. This may be empirically stated thus:—signal No. 4 off, and train moving in section No. 4, with section No. 2 dead and signal on. Signal No. 3 off, and train moving in section No. 4, with section

No. 1 dead and signal on. Signal No. 2 off, and train moving in section No. 2, with section *X* dead and signal on.

This system will not detect stationary vehicles of any kind, for only power-driven trains, *when moving*, will work their own signals, preserving one unoccupied block between successive trains; it is thus a useful circuit to

Fig. 121



use on continuous layouts on which a steady service of trains is being maintained; *e.g.*, exhibition layouts.

By the simple expedient of providing relays with two windings on their coils, one of 100 ohms resistance, and the other of ½ ohm, the circuit shown in Fig. 122 becomes possible; the relay coils are shown in diagram in Fig. 121, where the high-resistance winding is between *X* and *Y*, and the low-resistance between *X* and *Z*. Only one set of relay blades is required for each relay.

The operation of this circuit is as follows:—Traffic running from left to right, the first train (*T*1) in block in block No. 3A has energised the relay (*R*3) through its low-resistance coil (*X* to *Z*). The circuit from section No. 3 is complete to the high-resistance coil of relay *R*2, but open from section No. 3 to section No. 2A. The second train (*T*2) standing in section No. 3, passes enough current (either through its motor, or the track resistances to be explained) to operate relay *R*2 through its high-resistance winding (*X* to *Y*). Thus relay 2 is energised, and the circuit to section No. 2 is completed to the high-resistance coil of relay *R*1, and yet open between sections Nos. 1

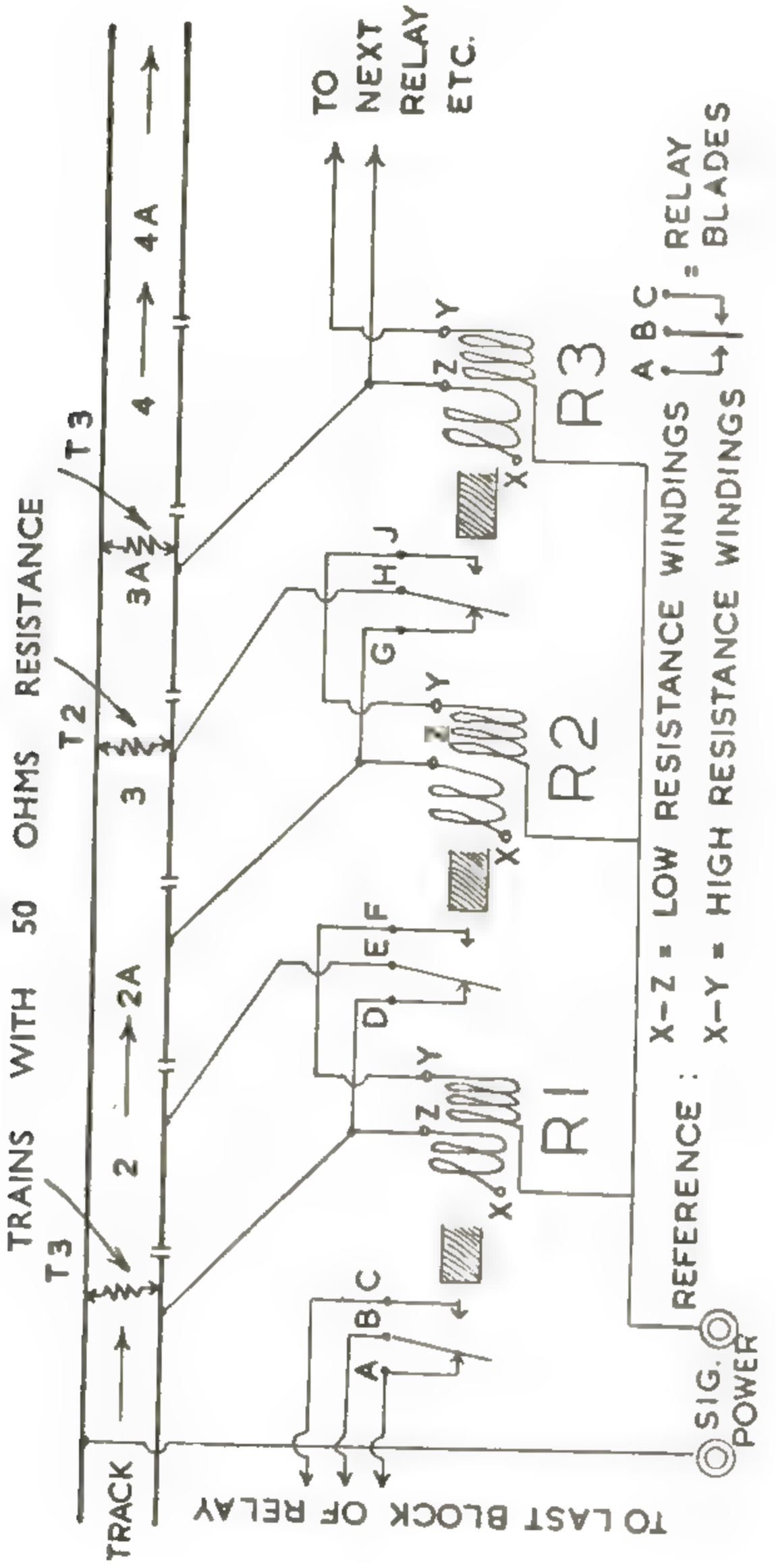


Fig. 122

and 2. As there is no train in either sections 1 or 2, relay *R*1 is normal (*i.e.*, not excited through either of its couls). A third train (*T*3) entering section No. 1 will continue to move whilst its locomotive draws power from the section *via* the low-resistance coil (*X*-*Z*) of relay *R*1; but when the locomotive enters the next section (No. 2) it will stop, because the resistance of the relay coil is too

high to pass enough current to operate its motor, though it will pass enough to energise its core. Train *T*2 thus cannot start until the last vehicle of *T*1 has cleared section No. 4, which thus leaves two unoccupied sections between the trains; therefore the protection is complete.

Protection is maintained over all vehicles by fitting them with 50 ohm resistors, placed from one track-wheel to the other, which is enough to pass sufficient current across the rails to keep the appropriate relay energised until the last vehicle has cleared the section. Without this slight flow of current, all protection would cease immediately the locomotive passed out of the section; also, any vehicle which might have been dropped from the train would be unprotected.

To save time, only guards vans and goods brakes need be equipped with the resistances, as one or the other of these vehicles should be at the rear end of any train moving on the running roads. The resistances to be used may be of standard radio composition pattern, quarter- or half-watt size being quite large enough to carry the current.

By fitting another set of blades to each of the relays in Fig. 122, it becomes an easy matter to work appropriate signal solenoids by means of an entirely separate battery-driven circuit, and the signal circuits already dealt with are suitable for the purpose. It must, however, be very clearly understood that any such signal circuit, if superimposed on that of Fig. 122 must be kept *entirely separate* electrically from the latter; the only point at which a liason exists between the two is that the relays move not only their contact blades *A*, *B* and *C*, but also a separate set of blades switching the signal motor current. The connection between the two circuits is, therefore, purely a *mechanical* one.

It may be said that often the value of relays and their multitudinous applications to model railway signalling do not appear to be fully understood; but a little thought and planning on the part of the reader will reveal many

other interesting ways in which they can be used with good effect; and if any of the types of which the construction has been explained are made in some quantity, there is no good reason why really rational, protective signalling should not find a place on even the smallest model railway layout. The matter is not one of expense or skill, but purely one of care and accurate adjustment, with *no* "slap-dash" wiring with twisted wires and poor contacts.

CHAPTER NINE

ALTHOUGH not strictly within the realms of "power signalling," the operation of electronically generated engine whistles can well form a welcome addition to any layout, upon which it will give a very real added operational interest.

It may not be generally known that there is an engine whistle signal code applicable to most signals on the running lines at junctions and crossings, which are used when the correct signal is not lowered. Also that trains requiring a pilot or banking engine, or approaching a tunnel, men at work, or a public level-crossing, always give indication by means of the locomotive whistle. There are also special whistle codes in force at certain places where the general running-line code does not apply, and there are cases where signalmen are enabled to describe a train forward by the whistle code of the engine approaching the signal-box.

The production of a good simulation of a locomotive whistle is not difficult and the circuit required for this purpose is shown in Fig. 123, where it will be seen that one radio valve is used, together with a small "low-frequency" radio type transformer, a tiny condenser (also radio type), and a midget loud-speaker.

In 4-mm. scale, there is, unfortunately, no possibility of this assembly being mounted on a locomotive, but in 7-mm. scale by the use of "midget" components, including a "deaf-aid" type of valve, the whole whistle unit can

sometimes be fitted in the boiler and tender of really large engines, if a little forethought and scheming are brought to bear on the problem.

In normal cases, however, it is simplest to mount the whole unit sub-baseboard in a convenient position, running wires to the loud-speaker unit which is placed at the point whence the sound is desired to proceed from *e.g.*, from a tunnel-mouth or a platform starting signal.

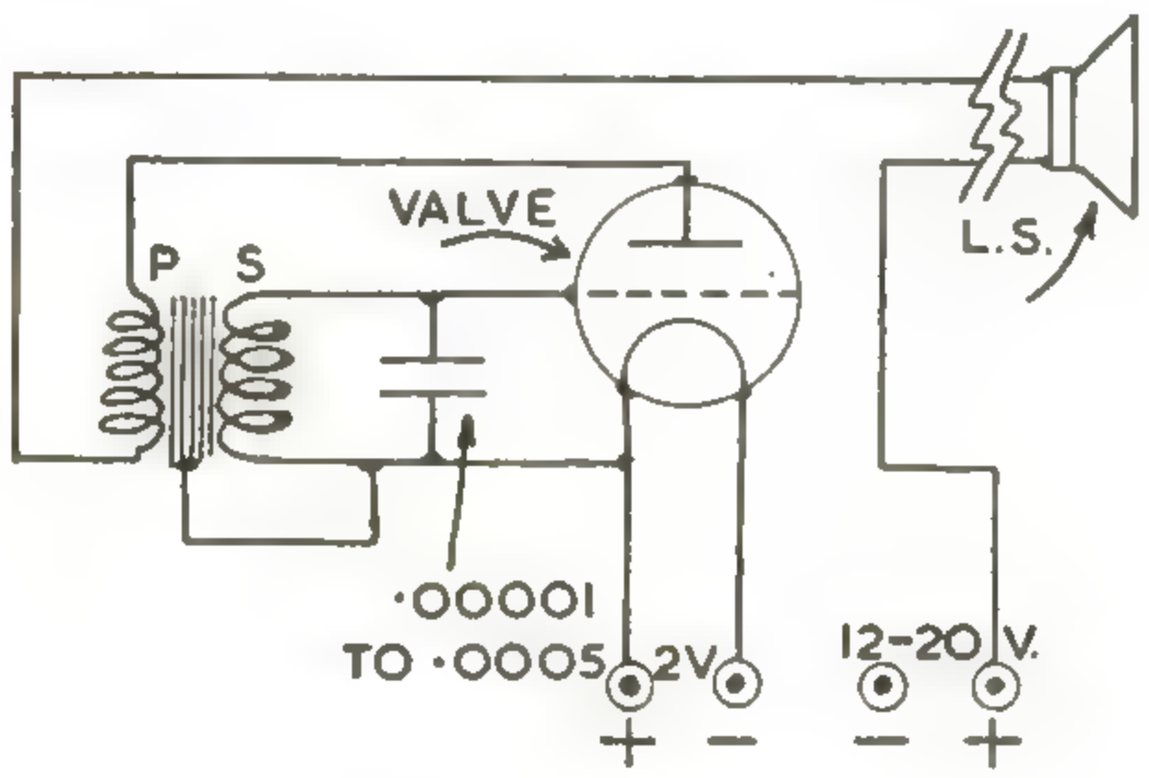


Fig. 123

Note : The two battery negative terminals must be joined.

In the circuit shown almost any 2- or 4-V battery radio valve may be used, some typical examples being Marconi HL2, L21, L210, DEL210, P215 or DEP215; Mullard PM1HL, PM1LF, PM2, or any other valve with similar general characteristics. If desired, 4-V valves of the same classes may be used.

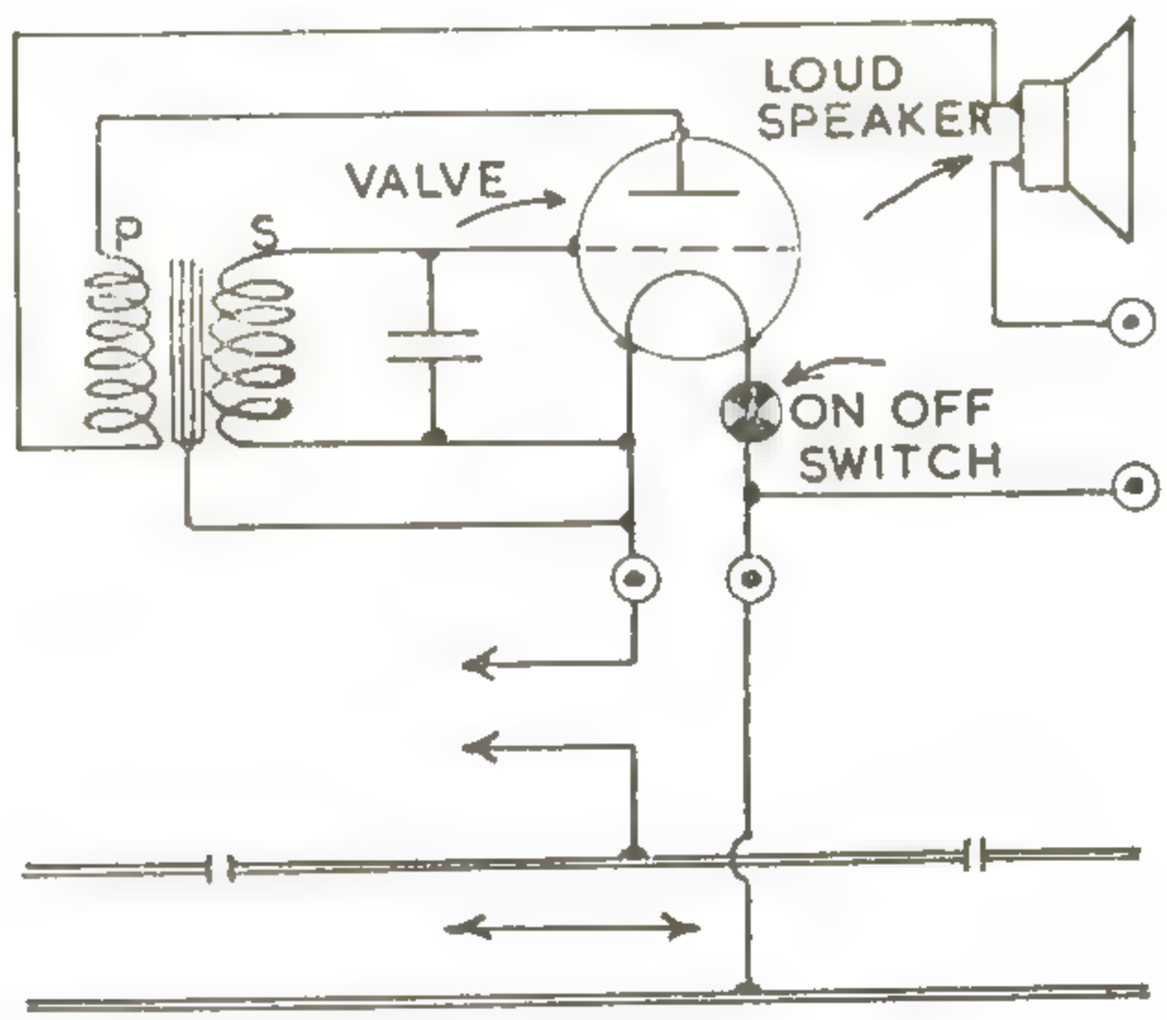
Any transformer having a 3- or 4-to-1 ratio is quite satisfactory, so long as its windings are not burnt out, whilst pitch control condenser in the valve grid lead is one of the small cylindrical type which cost but a few pence. Any type of loud-speaker may be used, as long as its coil is perfect; in fact, the writer has found that more realistic effects are produced when an old-fashioned horn type of loud-speaker is used.

The power supply consists of 12 V d.c. (derived from the rectified output of the traction power supply unit,) and the lighting circuit of the valve is fed from either a

3-V or $4\frac{1}{2}$-V dry cell, according to whether a 2- or 4-V valve is used.

As the windings of the transformer to be used are not known, nor the type of valve, it is impossible to give details of the capacity of the small condenser; so the latter forms

Fig. 124



the variable factor of the set, which is—in radio technique—known as a low-frequency oscillator. The condenser will need to have a capacity somewhere between 0.00001 mfd. and 0.0005 mfd., and a small variable air condenser of the latter capacity can be used with advantage, variation of whistle note being made by turning its knob. Such variable condensers are very cheaply obtainable from radio sources as aerial, grid, or anode tuning condensers, of various shapes and sizes. Fig. 124 shows a diagrammatic layout of the components, and it also shows how simple it is to construct and wire a whistle unit. The valve-holder used is of the "baseboard-mounting" type, and as this type is not used in radio today, it can be bought second-hand for a few coppers.

If the whistle is to be automatic, the circuit (Fig. 124) is best arranged so that the valve current is switched on and off by a normal track-circuit, but if manual operation

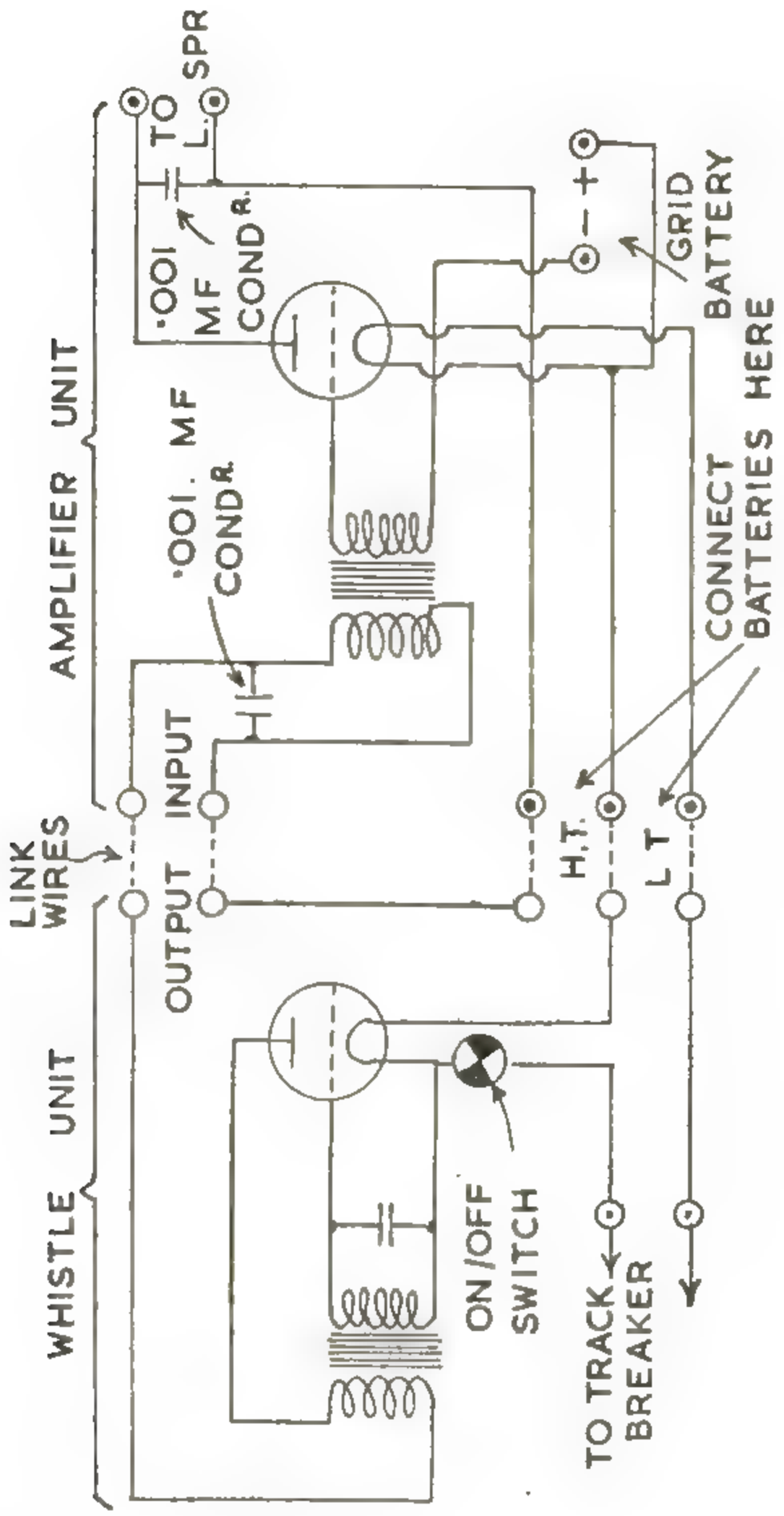


Fig. 125

is to be used, then it is advisable to break the high-tension and low-tension leads by a remote switch where shown on the circuit. This will save excessive battery drain on the valve heater battery by completely cutting out both batteries when the whistle unit is not actually working.

Care should be taken to wire the transformer as shown, with its " P " (primary) coil in the valve anode, and its " S " (secondary) coil in the grid; and if no result can be obtained the primary leads to it should be reversed *without* also reversing the secondary wires. If the transformer

terminals are marked *IP*, *OP*, *IS* and *OS*, *IP* should be taken in the first case to the valve anode, and *IS* to the grid, and *one* of these wires reversed if necessary (i.e., *IP* to anode, *OP* to loudspeaker, *IS* to filament of valve, and *OS* to grid). A little adjustment may be needed, by way of varying the capacity of the condenser or anode (high-tension) voltage, to produce a pleasant and realistic note from the speaker.

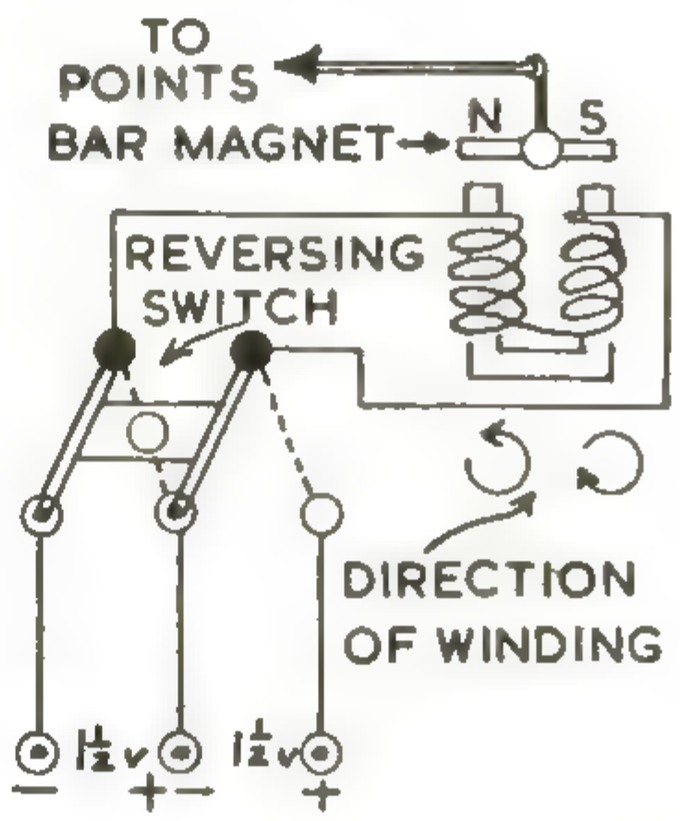


Fig. 126

If desired a much louder whistle can be obtained by adding a low-frequency amplifier as depicted in Fig. 125, in which case, again, the cost is negligible; another valve, transformer, valve-holder and 9-V grid bias battery are needed. In the writer's opinion, however, the production of a really loud whistle detracted from its realism—it seemed, in a queer sense "out-of-scale" and too over-powering, whereas a fainter note fitted in with the small-scale model aspect of the trains and layout much better.

Another type of switching circuit with interesting possibilities is that shown in Fig. 126, in which a polarised electro-magnetic motor is used and operated in either direction by means of two small dry-cells wired as illustrated, together with a manual reversing switch. The "motor" is made from an old permanent-magnet of any shape, wound with coils in the direction shown. When the current is fed to the motor from one battery, the armature

rocks toward one pole, but when fed in the reverse direction, it is drawn towards the other. It is, in effect, worked on the well-known "constant polarity" system—*i.e.*, with two batteries.

A useful "stick" relay circuit, in which the coil of the relay is a high-resistance one and constantly energised, is shown in Fig. 127. This principle enables a certain condition of locking of controls of various kinds to be

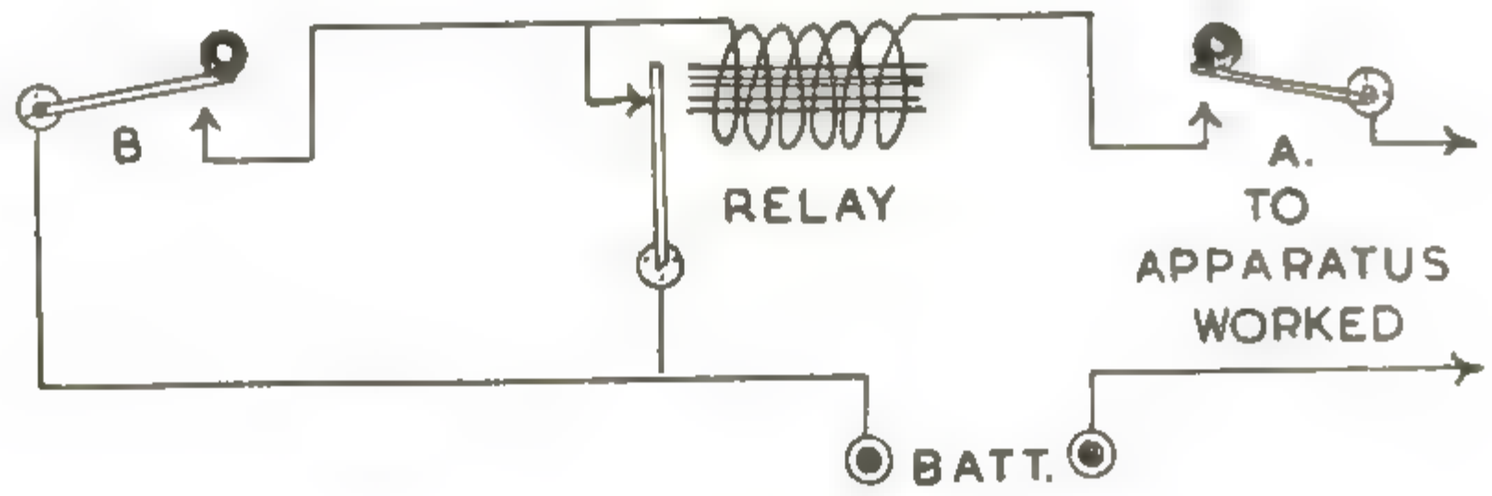


Fig. 127

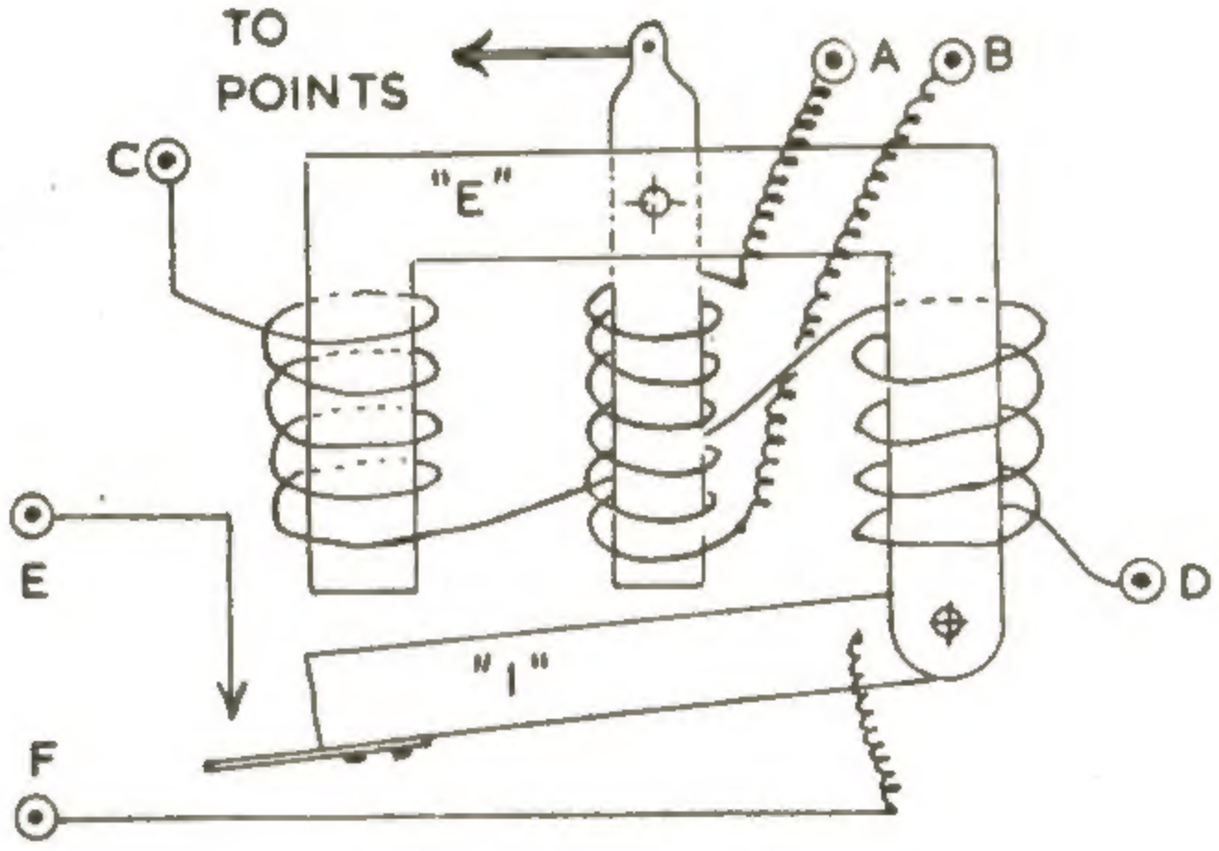
established at one moment, and held until the time comes for releasing it. Such a circuit is used in very many prototype positions, and it will be seen that pressing the key or bell-push *A*, releases the relay, which thus breaks the circuit from the battery to its own exciting coil, which thus cannot be re-energised until push *B* has been depressed.

A relay-*cum*-point or signal motor which works on the polarised principle without the use of a permanent magnet is shown in Fig. 128. In this case, the application of current to the terminals *C-D* will in any case cause the lower armature to close the circuit *E-F*, and at the same time move the upper armature towards pole *E* or *F*, according to the direction of current flowing through the upper armature coil, *via* terminals *A* and *B*. This swinging armature can be used for operating a signal arm or for closing another pair of contacts, as shown in the inset sketch.

A relay of this kind can be made very cheaply from the "E" and "I" laminations of a burnt-out radio output transformer, obtainable from any radio store. The inset

sketch shows how the laminations are used, and is self-explanatory. The windings of the three coils should be made either of high or low resistance, according to the work they have to perform.

Fig. 128



The use of motor-car generator cut-outs as relays for model railway purposes was mentioned earlier in this book, and for those who do not feel competent, or have not the time to make the relays mentioned in the last chapter, here is a method of converting motor-car cut-outs for model railway work.

In Fig. 129 is shown the general design of the average cut-out, in which two coils are used, one of high and the other of lower resistance; and it is with the latter only that we are concerned for model railway use. As the cut-out is not designed for such purposes, a certain amount of modification will be necessary before it can be used. (Fig. 130). The frame of the cut-out should be carefully removed from the base, and all four wire end connections (from the coils) unsoldered free from their existing contact points. One or other of these coils (according to the use to which it is to be put) is used, together with the contact on the armature; but as the latter is a " make " contact, it will have to be converted into a " break " by bending over the armature stop until it sets over the fixed contact

stud, so that when the coil is de-energised it flies back until the stud contacts the bent-over stop-pin. If possible a small piece of silver or German silver should be soldered to the stop, so that a good contact is made.

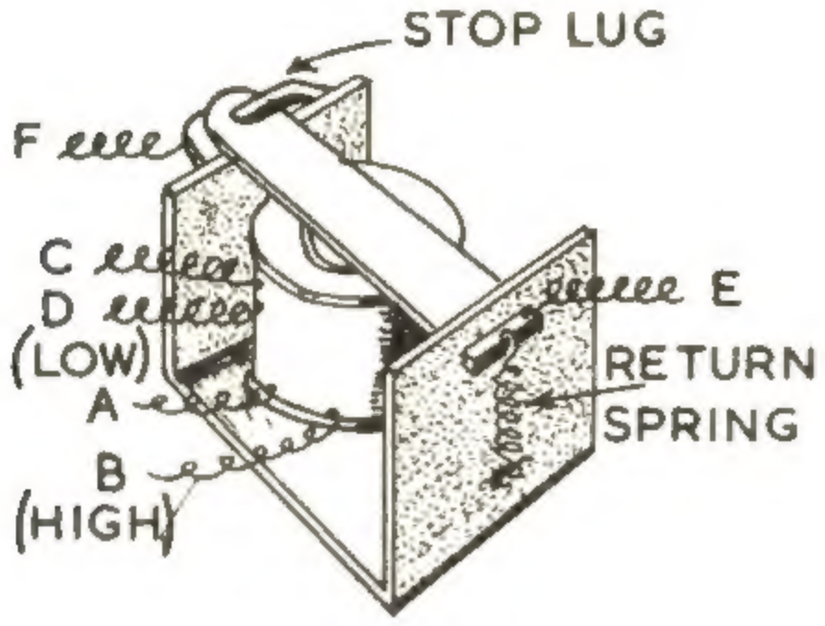


Fig. 129

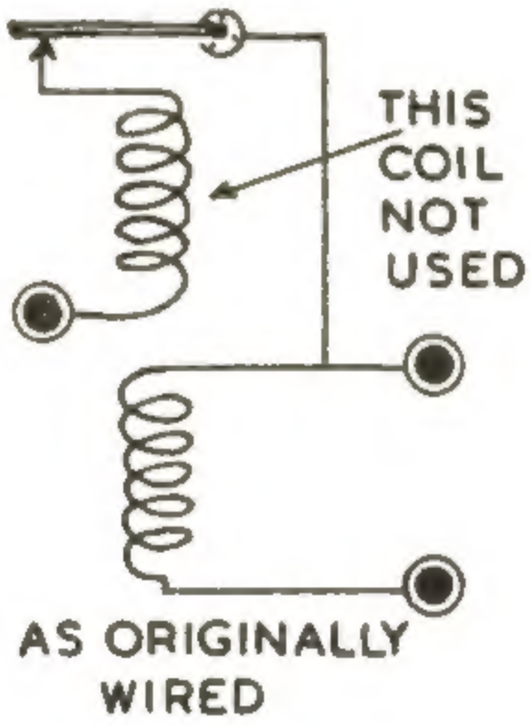


Fig. 130

The relay circuit now appears as shown in Fig. 131, in which energy to the relay coil is fed *via* terminals *X* and *Y*, and power to the signal lights (or other apparatus) *via Y* and *Z*. The two circuits may be entirely isolated from each other if desired by breaking the wire from the relay coil to the blades at *A*, and connecting the latter to another terminal at *Y*2, in which signal lighting feed is made between *Y*2 and *Z*. It should be noted that these relays are only suitable for d.c. operation, their coils working at the same voltage as that of the accumulators on the motor-car from which they were taken, usually 6 or 12 V.

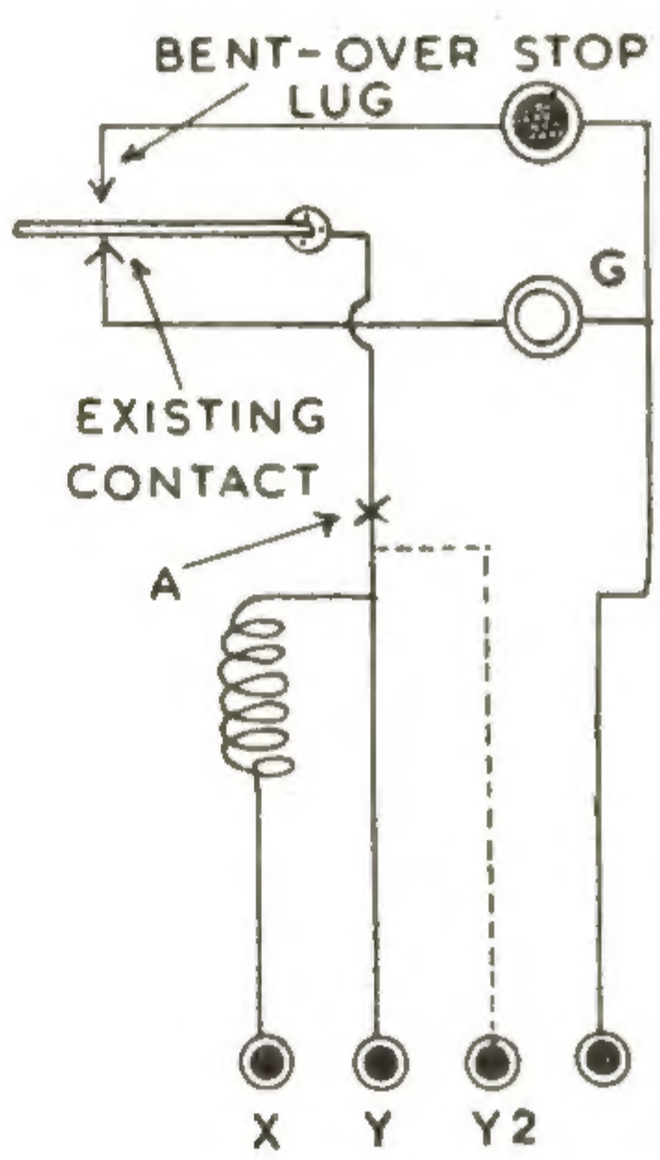
It may be said that these cut-outs can be readily purchased at almost any garage for a few pence each, and thus offer a very cheap source of relays for certain uses on a layout.

In bringing this book to a close, it must be said that in most of the apparatus the construction of which has been described, primary consideration has been given to low cost coupled with reliability, rather than to neat design. This decision was taken in view of the fact that, as most

of the electrical gear was well out of sight, excessive neatness did not enter into the picture, nor did it detract from any particular feature of the railway as a whole.

The actual "gadgets" enabling electric signalling and control to be worked on a model are only "means

Fig. 131



to an end," and should be treated as such. If they work well and are thoroughly reliable, that is all that should be required of them. Moreover, if the reader thoroughly appreciates this important point, needless hours of excessive care will not be spent making a "good-looking" job which will not operate any better than a strongly-made, yet unpretentious one.

To those readers who purchase their electric gear ready-made, the circuits are offered in the sincere hope that if what is actually needed for some special job is not to be found, sufficient "key" circuits will be available, from which the required arrangement can be formulated.

Electricity can be applied in so many ways, and there are so many different circuits available that it is impossible to even attempt an exhaustive description of them all. In this respect, it will have been noticed that only brief

mention has been made of the possibilities of the interlocking of traction-power and signals, which really belongs more to the realm of track electrification than to power signalling.*

* See "Electric Model Railways" Percival Marshall & Co. Ltd., London.